No. 21.

Colonial Museum and Geological Survey of New Zealand.

SIR JAMES HECTOR, K.C.M.G., F.R.S.,

DIRECTOR.

REPORTS

OF

GEOLOGICAL EXPLORATIONS

DURING 1890-91.

WITH MAPS AND SECTIONS.

PUBLISHED BY COMMAND.

NEW ZEALAND:
BY AUTHORITY: GEORGE DIDSBURY, GOVERNMENT PRINTER, WELLINGTON.

1892.

CONTENTS.

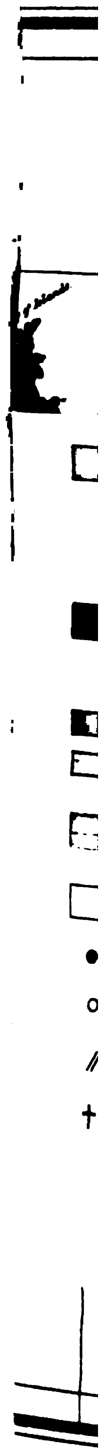
PROGRESS REPORT, BY THE DIRECTOR.

REPORTS.

APPENDIX.

LIST OF GEOLOGICAL MAPS, ETC.

SECTIONS.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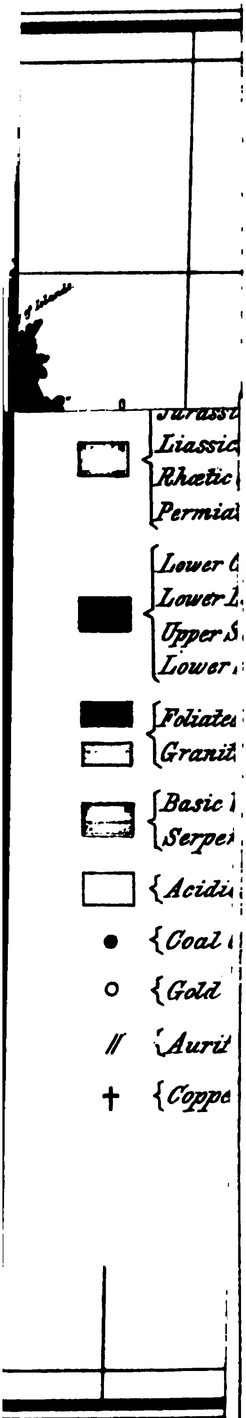


1883.

REPORTS OF THE GEOLOGICAL SURVEY.

PROGRESS REPORT, 1890–91.

INTRODUCTION.

THE reports which follow refer to the period from October, 1889, to May, 1891, and to surveys which have been made in the following districts of the colony:—

Eastern, interior, and southern part of Otago.
Northern Canterbury.
North and west Nelson.
Marlborough.
Northern Auckland.

At the Dunedin Exhibition the Geological Department was well represented by collections illustrating the mineral wealth of the colony, which included, besides most of the exhibits returned from the Melbourne Exhibition, a large series that was specially obtained for the occasion.

A special exhibit, consisting of a geological relief-map of New Zealand, on the scale of four miles to the inch, was at the close of the Exhibition presented to the Otago University Museum, together with other valuable collections.

The most interesting massive exhibits were those of antimony- and manganese-ores, several promising lodes of these ores having been at that time discovered and opened up in Otago.

The latter part of 1889 was almost entirely occupied with the arrangement of the Mineral Court at the above Exhibition, both the Director and Mr. McKay, the Assistant Geologist, being engaged on the work. Mr. Park having been transferred by the Government to the School of Mines at the Thames, the staff of the Geological Department available for field-work has since then been reduced to the two above-named officers.

The amount of field-work of the department was further reduced by the appointment of the Director as Chairman of two

Commissions—one to investigate the condition of the Dunedin Hospital, and the other to report on the dispute between the coal-miners and their employers in the Grey Valley Coalfield. On these Commissions the Director was occupied from August to December last, and the evidence taken and reports thereon have been published in Parliamentary Papers H.–1 and C.–3, 1891.

COLLINGWOOD GOLDFIELD.

Owing to the recent formation of a local company to promote ground-sluicing on an extensive scale at Parapara, near Collingwood, my attention has again been directed to the auriferous resources of this promising district.

The alluvial gold, of which nearly one million pounds' worth has been obtained in the Collingwood district, has been attributed to various sources. In 1860 Von Hochstetter, who examined the district while the first rush to these diggings had not fully subsided, was of opinion that the Aorere River and its tributary streams had been the chief agents in the liberation of the gold from its original matrix and its distribution through the extensive gravel terraces that skirt the wide valley of that river; and, assuming that the gravels were equally auriferous throughout, he ventured on calculations founded on the cubic contents and the average yield of some of the deposits that had been worked.

Von Hochstetter, from various tests which he describes in detail, assumed that the surface-gravels were auriferous to an average depth of one yard over an area of thirty square miles, and that each cubic yard of gravel contains five shillings' worth of gold. The computation on this basis promised a yield of £22,500,000. (Hoch., N.Z., p. 106 : Eng. Trans.)

On the other hand, my own surveys of this goldfield in 1866, and on several subsequent visits, had convinced me that the gold was chiefly derived as a rewash from an ancient alluvial drift, the distribution of which was quite different in its origin from the present drainage system of the country. This has also been the idea underlying the reports of various geological surveys of subsequent date, such as Hackett, Davis, Hutton, Cox, and Park, all members of the Geological Survey staff, but they still only attributed the richer alluvia to former channels of the Aorere River system that remain at a high level along the eastern side of the more recently excavated Aorere valley of the present period.

The late Mr. Davis gave in 1870 the following description of the nature of the auriferous deposits: "Immediately on leaving Collingwood a large tract of alluvial ground is entered on, which stretches away some eight or nine miles in a south-west direction. This plain is bounded on the north-west by the Aorere River, on the north by the sea, and on the east by the Parapara; towards the south-west the drift-deposit of which it is composed ends on the slopes of slate and schistose hills near Bedstead Gully, &c. The most striking feature about this flat land is the succession of terraces by which it rises as it recedes further inland, and also a few island-like rocks which here and there rise up above the level of the surrounding drift. The drift is composed almost entirely of quartzite, quartz, and schist in rolled pieces, but in a few instances I noticed the presence of subangular fragments. Gold may be found in all parts of the drift, but only in payable quantities in a few localities, which appear to me to be those places where the materials have been re-sorted and the gold concentrated by the action of running water subsequent to their original deposition." (Geol. Rep. 1870–71, p. 131.)

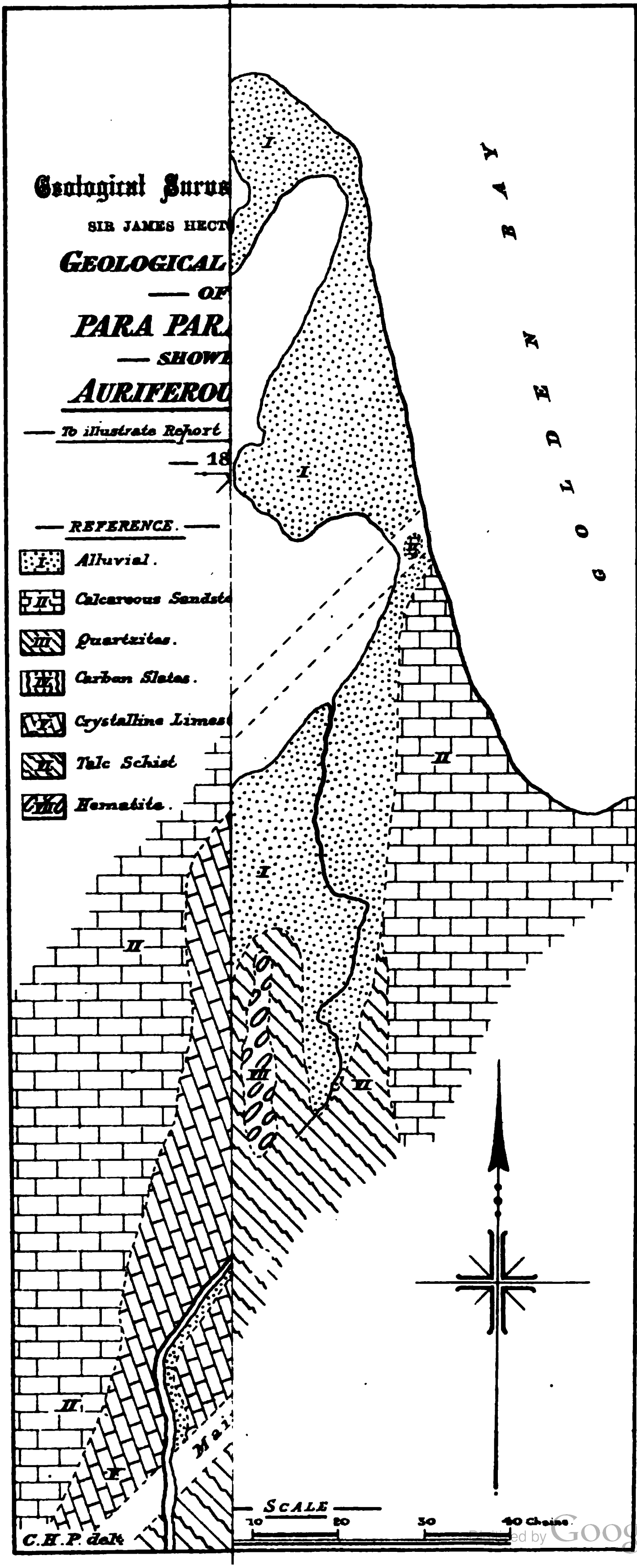
In partial support of this view, Professor Hutton attributed the wonderfully rich deposits at Golden Gully to the denudation of the schists on which they rested, and claimed the schist as the source of the heavy deposits of quartz pebbles that form the auriferous wash. (Geol. Rep. 1871–72, p. 152.) Mr. Cox was, on the other hand, explicit in opinion that the drifts were not local. Speaking of the high-level auriferous gravels, he says, "It appears probable, following the line of this deposit, that it was originally brought from the direction of the Gouland Downs, the river which deposited it flowing at a much higher level than that taken by the Aorere now. It was, moreover, in all probability fed by glaciers, so that the rocks may have been brought from a considerable distance, the fact that quartz forms the principal constituent of the gravels being accounted for by its resistance to disintegration compared with the comparatively soft rocks with which it was associated. That these gravels were brought from a distance, and in no way derived their origin from the immediate vicinity, is, I think, sufficiently borne out by the fact that granite is practically unrepresented in the wash, while the granite mass of Lead Hill cannot be more than two miles distant in a direct line, "A similar state of things is represented by the old gravels in Glengyle Creek and Richmond Hill, which were undoubtedly deposited by the Parapara while it flowed at a much higher level than at present; and the Waiangaromumu Diggings offer yet another instance of this ancient series of river-gravels." (Geol. Rep. 1881, p. 55.)

Mr. Park, on the other hand, sees "no reason for calling in the aid of this ancient and hypothetical river, of which no trace whatever remains. The drifts are mere patches in extent, and could easily have been formed by the present streams at the time when their courses were steeper, and their transporting-power thus proportionately increased. Besides, the material forming the drifts is obviously derived from the area within the watershed of the streams on which they occur. In Washbourne's old claim angular fragments of soft slate are not uncommon, showing that they have not travelled far." (Geol. Rep. 1889, p. 242.)

I have never felt altogether satisfied with the explanation that attributes the origin of the gold to the ordinary drift gravels, and have visited this goldfield on many occasions during the last twenty years with a feeling of surprise that such enormously rich finds should have been made in the early days, and that they should not have been followed up, as in other gold-mining districts, by more permanent, though perhaps less rich, discoveries. Want of concentrated energy and capital, in order to secure a sufficient water-supply to enable the modern methods of mining to be adopted, has seemed to me the chief difficulty, and it was with great interest that I lately took an opportunity of re-examining a property there on behalf of the Parapara Sluicing Company, which seems to be the first effort that has been conceived on the right method of working for the proper development of the district.

In this special examination I was accompanied by Mr. Adams, who has been engaged in practical mining in this district for nearly thirty years, and who gave me suggestive information about many workings that are now abandoned.

The results of my investigation can be more readily understood by inspection of the accompanying plans which I have prepared. Plan A shows the general distribution of the auriferous gravels in the district, from the coast-line at Parapara to Boulder Lake; while plan B is a geological sketch-map of the particular locality of the proposed mining operations.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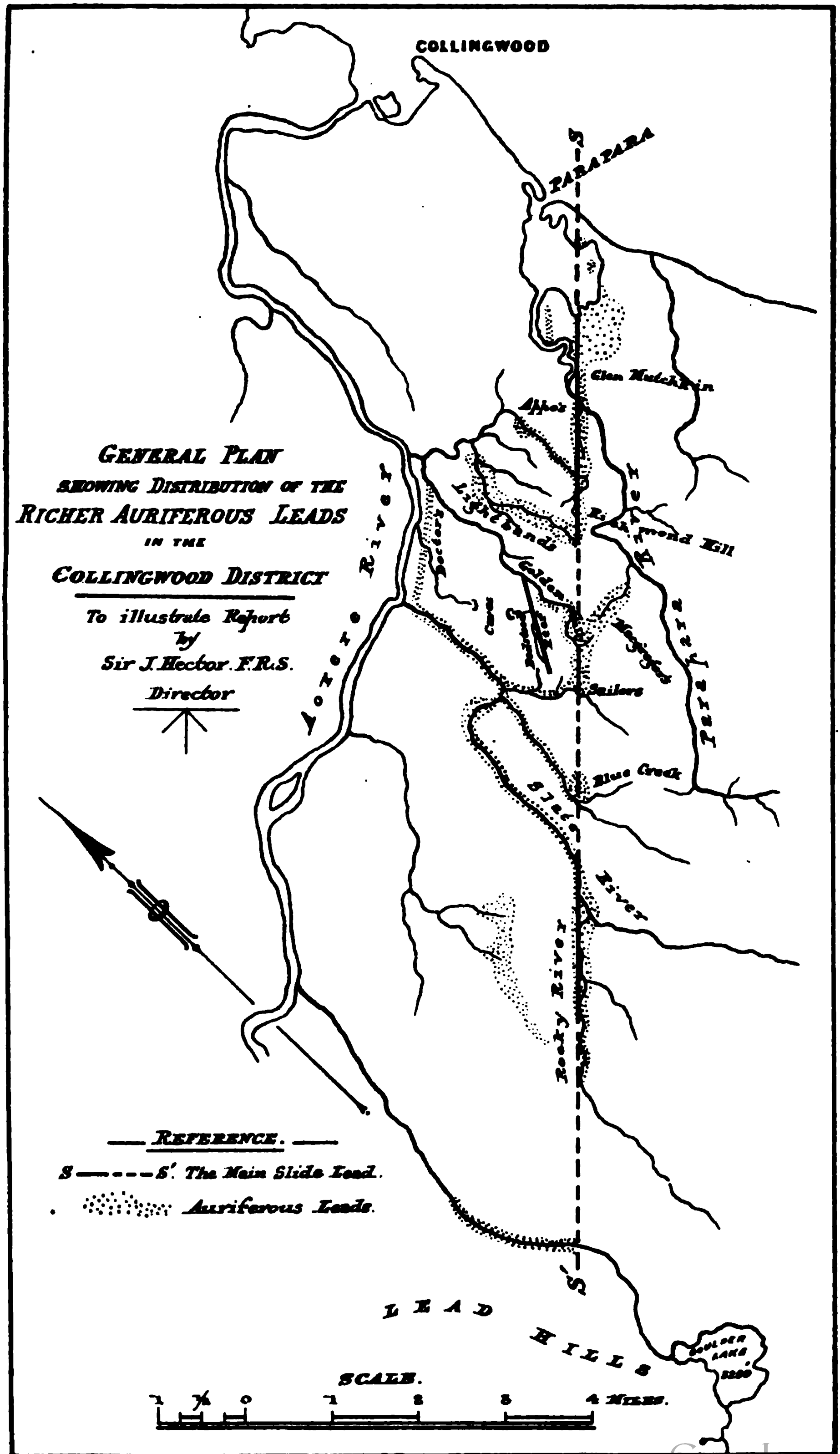
Geological Survey of New Zealand.

SIR JAMES HECTOR, F.R.S., DIRECTOR.



Parapara is named from the old Maori settlement which was situated round the extensive tidal lagoon where a stream of moderate size enters the sea three miles east of Collingwood. At full tide this lagoon has a picturesque appearance, but at low water it is only a mudflat intersected by runlets of water. I found Maori remains abundantly in the early days on the sandspit, and on a small islet in the centre of the lagoon, which, from the stumps of the old piles and large shell-heaps, must have been used as a landing-place.

On the south side of the lagoon are alluvial flats, surrounded by low hills largely composed of bog-iron ore to a height of 200ft. above the sea-level. These valuable deposits, which are at present worked for the manufacture of hæmatite paint, have been fully described in previous reports. (Geol. Rep. 1878–79, p. 59). The iron-ore occurs associated with coarse gravels which have for many years been worked in an irregular manner for gold. Gold was also washed out from the sands on the sea-beach at the mouth of the river, and along the coast to the eastward; also in the bed of the river, as far up as the first gorge, about a mile from the tidal water. At one time there was a considerable mining population in this district, but, owing to the difficulty of procuring a sufficient water-supply for sluicing the gravels, the miners gradually abandoned the place. From the first gorge the gold seemed to leave the Parapara River and follow a line to the south-west, crossing a succession of low saddles that divide the waters of various streams, and intersecting the richest diggings, such as Glenmutchkin, Glengyle, Appoo Creek, Richmond Hill, Golden Gully, and Rocky River. It was at Golden Gully that the first important discovery was made, and from report the richness of the claims was most remarkable. The sinking was only 5ft. deep, and I find the area worked was only about 50,000 square yards. This gives about 100,000 loads. From this area in a few months 40,000oz. of gold was obtained and sold on the ground to storekeepers, or at the rate of nearly ½oz. to the load. Patches of the ground were, however, so rich that the yield was frequently 1oz. of gold from a single dish of stuff; and yet only a portion of the gold was secured, as the tailings have been worked over and over again, and a few miners are still so employed.

The gold in this instance was obtained from a thin layer of loose quartz-gravel resting on the denuded surface of soft slate rock; but along the east side of the shallow diggings deep ground was discovered, and at the head of Blue Creek a shaft 120ft. deep was sunk in a very compact, coarse conglomerate without reaching any bed-rock. Gold was found in every part of the conglomerate taken out, but, on failing to find a definite lead, the work was abandoned.

The workings in Appoo Gully also throw light on the peculiar distribution of these auriferous gravels. In its upper part the creek follows a line of the deep ground, but crosses it obliquely, so that towards the Richmond Hill saddle, the lead has been smothered by heavy landslips from the eastern side of the valley. Lower down, where the richest surface-workings were situated, deep ground was discovered, and a shaft was sunk by Messrs. Travers and Washbourne; but—so I am informed—this prospecting work was also abandoned at a depth of 140ft., without any gutter or lead being found, or any change being encountered in the nature of the material.

The gold-bearing lead continues to follow a bearing of N. 40° E. over the saddle which separates the Hit or Miss Claim from Glengyle Creek; and just above the junction of the latter creek with the Parapara River a third trial shaft was put down in cement ground from the river-level to a considerable depth, and this shaft also failed to disclose any change or limit in depth for the deposit.

It thus appears probable that we have to deal with a more or less vertical stratum of auriferous gravel or cement which follows a fault-line—which for convenience I may term a main slide—that is independent of the present contour of the country, and that we have also to deal with secondary and concentrated gravels derived from this main-slide cement.

This view is supported by the following well-ascertained facts: (1.) Streams which intersect the line of the main slide are auriferous only in that part of their course which is below the intersection—such for instance as Parapara River, Appoo

Creek, Lightband Creek, Golden Gully, Sailor and Blue Creeks, Slate River, and its tributary, Rocky River, as shown on Plan A. (2.) Smaller streams which intersect the terrace gravels in lines parallel with the above, but rise short of the intersection of the main slide, are not auriferous. (3.) There are several auriferous reefs in the district now being worked by Johnstone's United Company which yield gold of a different chemical quality from that in the main-slide cement, the latter being extremely pure and bright, while the former is tarnished by contact with arsenical pyrites and other metallic sulphides. Now, the area where these reefs crop out at the surface is isolated from the main-slide gravel, and within this area—as for instance in Bedstead Gully and Cole's Creek—all the alluvial gold, of which a considerable amount was obtained in the early days, had a characteristic greenish tarnish and a garlic odour on being heated, which proved its local origin from these reefs, and thus accounts for its presence under circumstances that precluded its having been derived from the main slide.

Nature of the Main Slide.

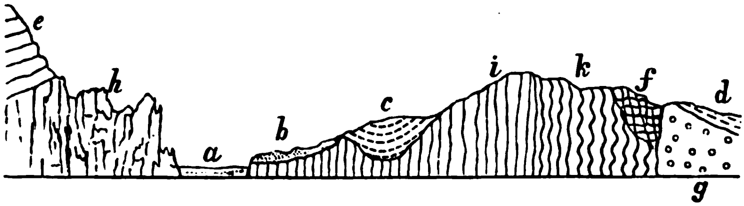
From the sections which have been displayed by the hydraulic-sluicing operations in Glenmutchkin, Glengyle, and Appoo Creek the main slide appears to have vertical walls about 180ft. apart, but at Richmond Hill the walls approached to within 30ft. at the surface, but in the deeper workings the fissure again acquired its full width.

The gravels which occupy the slide have a rude vertical stratification, but irregularly so, owing to the varying coarseness of the material. Many landslips have greatly obscured observation since I first examined this singular deposit on the 17th December, 1866, when I made the following note: "The boulders in the Glengyle Claim are of an immense size, and are expensive to move, a tram and incline being employed. The wash consists chiefly of boulders of very brilliant white quartz, sometimes solid and highly polished, but also occurring not infrequently in subangular and crystalline masses, friable and full of geodes lined with crystals, some of these rock-crystals being several inches in diameter. Among the large boulders are rolled pebbles of red chert or siliceous hæmatite, which are very characteristic of this cement, and large masses and crystals of mundic (iron-pyrites), the surfaces of which are rusted to dark brown iron-oxide. The cementing-material is a tenacious white or red pipeclay. These gravels continue to the saddle, 10 chains above the workings and 300ft. above the sea-level. Here I observed a vertical mass of pure white quartz-cement about 8ft. thick in contact with a vertical wall of black rock on the north-west side, but the ground was much slipped, so that the nature of the junction on the east side could not be clearly made out. Southwards, a sharp drop of 100ft. led to the gully of Appoo Creek above the gorge. In the opposite or north-east direction this vertical stratum could be clearly seen to cross the Parapara River and appear on the opposite side in a direct line through the Glenmutchkin Claim." In this claim both the walls of the slide have been exposed since the date of this note, and are seen to be in contact with black pug or clay containing graphite, and patches of carbonaceous matter, which are also scattered through the auriferous cement. At Richmond Hill indistinct fossil plants were obtained in vertical shale-beds in contact with the gravel on the west side of the slide. On the east wall of the slide the black clay in vertical layers does not appear to be carbonaceous. At the head of Sailor's Gully what has been described as a patch of coal-formation by Professor Hutton may probably be a highly carbonaceous portion of the slide material which has been involved in the fault. (Geol. Rep. 1871, p. 152.)

Besides the main-slide lead several other well-defined leads or deposits, formed by the rewashing and concentration of the main lead, require particular description. These have been distinguished as follows: No. 1, or Maori Lead; No. 2, or Washbourne's Lead; No. 3, or the Hæmatite Lead; and No. 4, or the Parapara sluicing-ground. The material of these can generally be distinguished from the cement of the main slide with ease, owing to the incoherent sandy nature of the matrix, and the abundance of hydrated iron-oxides; also, when close to the main lead, their secondary derivative character is shown by the abundance of rolled boulders of cemented conglomerate derived from the main lead which they contain.

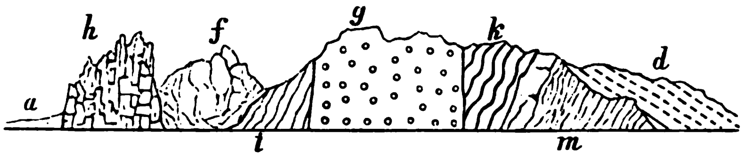
The relation which the main slide bears to the bounding rock-formations can be understood from the plan and the following sections:—

Section A is across the Parapara River, through Marshall's Flat and the No. 1 Lead.

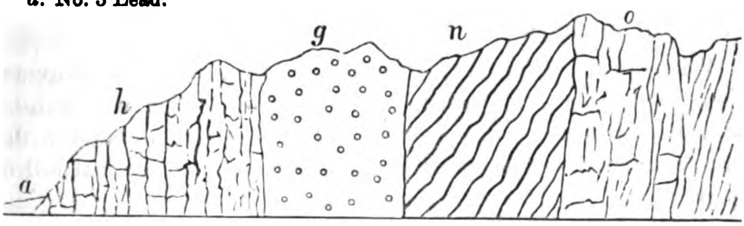


a. Parapara River. *b.* Gravel terrace. *c.* No. 1 Lead, or No. 2. *d.* Rewash derived from and resting on the main slide. *g–f.* Massive deposit of hæmatite. *c.* Calcareous sandstone and limestone of Tertiary age, resting on *h*, blue crystalline limestone of Silurian age. *i.* Feldspathic and mica-schist, passing into *k*, black carbon schist.

Section B is through the No. 2 Lead, from Caldwell's Flat to the paint-works.

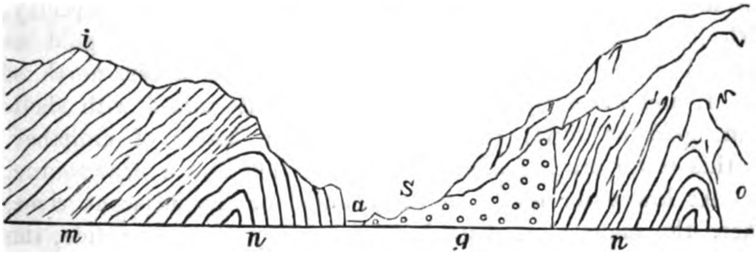


a. Caldwell's Flat. *h.* Crystalline limestone. *f.* Isolated mound of hæmatite. *i.* Mica-schist. *g.* The main slide. *k–m.* Talcose schist and steatite. *d.* No. 3 Lead.



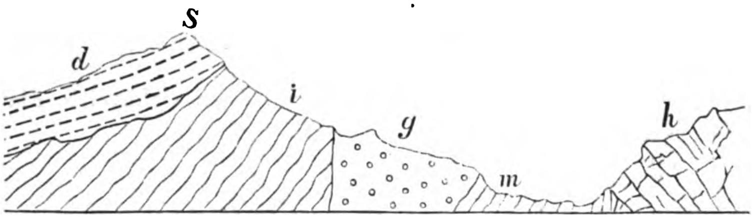
In Section C, which is taken through the spur north of Glenmutchkin Claim, in which the gravels of the main slide are exposed at 300ft. above the river, we find that the slide material, *g*, is bounded on the west by the crystalline limestone, *h*, and on the east side by talcose-schist, *n*, which on the top of the hill passes into massive steatite.

The Section D, across Appoo Creek above the gorge,



shows—*i*, feldspathic and quartz-schist; *m*, hornblende and schorlaceous schist, passing into *n*, gabbro-rock, as seen in the Red Hill tunnel. The valley, *s*, is excavated in the main slide, *g*, on the east side of which are much-decomposed magnesian rocks, *n*, passing into *o*, steatite.

Section E is across the Parapara Valley at the Richmond Hill bend, and through the head of Lightband's Gully, *s*.



On the west side we find the heavy deposit of rewashed gravel that formed Lightband's Diggings. It rests on *i*, feldspathic schist, which bounds the west side of the main slide; while *m*, compact hornblende-schist, bounds the east side, and is followed by crystalline limestone, *h*.

With special reference to the amount of gold in the alluvium it is necessary to recapitulate. Commencing at the sea-beach on the sandspit which encloses the Parapara Inlet, we find a deposit of auriferous-quartz gravel passing under a conical hill of "papa rock" smothered in sandhills.

Along the sea-cliff to the eastward the section exposes papa rock (indurated clay-marl with septaria), capped by stratified gravels which were, thirty years ago, worked for gold by tunnels, and afforded large returns. The source of the gold must have been close at hand, and it was no doubt derived from the outcrop under the sea of the main-slide lead above referred to. Four tests were made of the quartz-gravel on the sea-beach, with the following result: (1.) In main-slide stuff, 5ft. below the level of the mud-flat, in white quartz sand, and pipeclay, with large boulders of white quartz and red chert, gold at 3dwt. 15gr. per ton. (2.) Six feet below low water, north of No. 1, and evidently a rewash from it, intermixed with shell-sand, gold at 2dwt. 15gr. per ton, with traces of cinnabar. As this latter ore is friable its presence indicates a near source. (3.) At low-water mark, in the channel of the adjacent river, where the material is disturbed with every change of tide, the gravel yielded 6dwt. 10gr. per ton. (4.) At high-water mark, in the present channel, in muddy gravel resting on papa rock, at the rate of 5dwt. 19gr.

Following the line inland or southwards the lead is lost under the mud-flat for over a mile, but rich auriferous gravel reappears in the Parapara diggings in the superficial layers of the main lead, and chiefly in the redistributed material derived from it, which has in this locality been spread over an area of some 300 acres, probably by an ancient outfall of the Parapara River from the direction of the head of the mud-flat.

In the Parapara Sluicing Company's ground there are several secondary leads, as distinguished on Plan II. No. 1 is parallel with the present river where it enters on the mud-flats, and occupies a groove or channel along the west side of the long spur that projects into the valley, and which is crossed by the telegraph-line and inland track. This lead has been opened in two places 10 chains apart. Firstly, what are called the Maori workings, about 60ft. by 60ft. and 20ft. deep, gave 15oz., which is at the rate of about 1dwt. per load. The bottom of the gutter was not reached in this excavation, which is irregular in form, and was evidently very imperfectly worked. A special trial was made by slipping down 1ft. from the eastern face, or 50ft. by 20ft. by 1ft., or 120 loads, and this gave 4oz., or ⅔dwt. per load; but, owing to the very rough bottom, and the absence of proper fluming, the washing-up was very imperfect. Higher up the gutter a tunnel was put 70ft. by 4ft. by 3ft., and gave 18oz., or about 3½dwt. per load. This is probably the fairest test that has been made. The width of the gutter is about 2 chains, and the length for which it has been traced is about 20 chains. The sides of the gutter dip at about 1 in 3, and its cubic contents is about 150,000 loads, and, taking the yield at 2dwt. per load, it should yield about £60,000 value.

Following the water-race round the large bend of the river, we find it cut into fine-grained mica-schist, succeeded on the west side by carbon-schists, and then by crystalline limestone.

The east side of the valley now cuts through the old rocks and into heavy beds of white- and red-quartz gravels, dipping 70° W. to N.W., and constituting the No. 2, or Washbourne's Lead. In the gravels are heavy beds of black, soft sandstone, consisting chiefly of mica-sand, pyrites, and graphite. This stratum often resembles coal. The wash at this place is evidently a rewash to the present river valley prior to its complete excavation to the present depth, and it is probably the source of the No. 1 Lead.

This No. 2 Lead has been worked in a very irregular manner, and is now difficult of definition, but it may be estimated as 8 chains in length, with a cross section of 120ft. by 24ft. This will give a cubic contents of nearly 50,000 loads. Five tests were made with the pan, and gave, at per ton, from the white wash, 4dwt.; from the black wash, 1dwt. 6gr.; from the hæmatite, 3gr.; from close to the west side of the lead, 1dwt. 17gr.; and close to the east side, 2dwt. 20gr. Taking for the average 2dwt. per load, this will give, with the above, an estimated value for the No. 2 of £20,000.

No. 3 Lead, 10 chains east of No. 2 Lead, is in Peaty Gully, where there was a patch of very rich diggings, up to ¼oz. per pan having been taken from the surface-wash. The bottom was on a very tough cement. Where this bottom changes a black pyritous layer appears like that in the saddle diggings above described. All the old workings average only 2ft. depth of sinking, but in the line of the main slide, or No. 4 level, the bottom is on a brown layer of "pug," covering a hard gravel cement. In this material, some twenty years ago, at 20ft. above the level of the sea, two shafts were sunk—30ft. and 40ft. respectively—into solid wash without reaching any bottom, and the stuff put out yielded on the average 16dwt. per load. Close to these shafts, in a paddock worked by Messrs. Washbourne and Marshall, under the surface-gravels and below the brown pug or false bottom, the yield was 2oz. per man per diem. This paddock was bottomed on gravel cement, underlying and older than the black pyritous deposit. So far as seen, with these exceptions, all the old workings in this place have hitherto been in a surface rewash, with seldom more than 2ft. to 3ft. stripping.

The gravel of No. 3 Lead seems therefore to have been dispersed in a thin layer over an area of about 40 acres, and a rough estimate of the contents gave 2,000,000 loads, which, at 2dwt. per ton, would give a value of £800,000.

No. 4 Lead is the ground formerly worked by the Parapara Hydraulic Company. The colour of the gravel is red, and it is evidently a rewash from the main slide accumulated on a steep slope. Fourteen samples from this deposit were tested, with results varying from 2gr. to 9dwt. per ton. The richer samples were taken from the deeper and undisturbed ground, as most of the gold has been removed from the gravel formerly passed through the sluice-boxes, and which now forms the top layer. The lead is fan-shaped, and rises at a moderate angle to about 200ft. above the flat, with a width of 350ft., and total length of 600ft. Its cubic contents has been estimated at 1,500,000 loads, which, at 2dwt., would give a value of £600,000.

The Main Slide Lead, as already explained, is a deposit of auriferous gravel that is contained between more or less vertical walls. Within the new Parapara Company's ground it rises to 300ft. above the river, with a width about 260ft., as measured in the old Glenmutchkin workings. On the north or seaward slope no ground has been opened in this lead, but the gravel is seen to be continuous along the surface.

The easiest way to prove the nature and value of this deposit would be to tunnel through the narrow wall of crystalline limestone from Caldwell's Flat at the lowest possible level. Such a tunnel would prove if the lead really plunges between vertical walls in the manner it appears to do in the Glenmutchkin Claim. Assuming that it really does so, then the cubic contents above the water-level would be about five million loads.

The average richness of this old cement is very difficult to estimate. In the Glenmutchkin Claim two men working with a feeble water-supply are reported to have taken 40oz. with one week's work. The only fair test which I was able to make was by gathering rolled fragments of the cemented conglomorate from the No. 4 Lead, and on crushing them they were found to yield very uniformly at the rate of 2dwt. 20gr. per ton. Taking the average as 1dwt., the value of gold in the portion of the Main Slide Lead in the company's ground would be about £1,000,000. If the lead extends in depth, and is continuous under the mud-flat to the sea-coast, it would present a most favourable field for dredging and working by hydraulic excavation, and probably an additional amount to a value of £500,000 could thus be extracted.

These figures appear to be large, but from the tests made, and the past experience in the district, the estimates appear reasonable. They may be summarised as follows :—

Lead.	Cubic Yards.	Per Load or Cubic Yard.		
		At $\frac{1}{10}$dwt.	At 1dwt.	At 2dwt.
		£	£	£
No. 1 ..	150,000	3,000	30,000	60,000
No. 2 ..	50,000	250	2,500	5,000
No. 3 ..	2,000,000	40,000	400,000	800,000
No. 4 ..	1,500,000	10,000	300,000	600,000
Main Slide ..	5,000,000	100,000	1,000,000	2,000,000
Deep workings ..	2,600,000	52,000	520,000	1,040,000
	14,800,000	295,250	2,952,500	5,905,000

It is interesting to note that from much less rich gravels, averaging only 2gr. to the ton, at North Bloomfield, in California, in three years' work, 30,000,000 cubic yards of gravel was washed, with a gross yield of £520,000 value. In working the Parapara Main Slide Lead, however, there would be an extra expenditure required for crushing and puddling, as probably not more than one-half of the material could be thoroughly disintegrated by the hydraulic nozzle alone.

The distance to which the main slide extends to the south-west is probably not less than ten or twelve miles, until it is cut off by the granite-spurs of the Lead Hills; but the determination of this important question requires a further survey of the country. It is important to note that, in the event of sluicing operations extending in this direction, an abundant water-supply could be obtained by damming the outlet of Boulder Lake, so as to retain the storm-water. This lake is 3,200ft. above the sea, and only thirteen miles in a straight line from the coast; so that, with a proper system of fluming, it could supply the whole line of auriferous country with a high-pressure water-service.

BLUE SPUR, TUAPEKA.

Since the first discovery of this remarkable goldfield in 1861, gold to the value of £4,500,000 has been extracted almost entirely from the shallow surface-gravels in valleys occupied by insignificant streams. No important quartz-reefs have been discovered, nor is the geological formation of the country such as to favour the idea that the gold is of local derivation. Its source is generally recognised to be from a patch of very peculiar blue cement or conglomerate, about a hundred acres in extent, and known as the Blue Spur. This cement has frequently been described as forming the main spur which divides the sources of Gabriel and Monro Gullies; but this is not correct, as both these gullies take their rise a considerable distance above where they intersect the cement; and it is an important point that above the cement they did not yield gold, although so extraordinarily rich in their lower parts. It was difficult in the early days to ascertain the true relation of this singular patch of cement, and it was generally considered to be an isolated portion of an ancient high-level river-bed that had descended from lofty mountains to the westward, the valley boundaries having since been removed by denudation. Professor Hutton considered that it was a river-deposit that had filled a cup-shaped hollow, or ancient mountain tarn that had originally been excavated by a glacier (Rep. on Geol. of Otago).

Mr. Cox (Geol. Rep. 1878–79, p. 49), observing at a later date, when more work had been done, describes the cements as occupying a basin or trough, the north-east side of which is very steep, while the south-west side is more shelving; and he gives the thickness of the cemented gravel as 300ft.

I lately visited the locality, and found so much of the cement-formation had been cleared away that its relation to the bed-rock is better displayed than formerly. The cement itself consists of confused subangular breccia, in regular layers, 1ft. to 10ft. thick, interbedded with grey-green sand and massive water-worn boulders varying from several feet to a few inches in diameter. These are generally of the very hardest rock, derived from the aphanite breccias of the Te Anau or Devonian formation; and the nearest place where such rocks are found *in sitû* is the Greenstone Valley, on the west side of the Wakatipu Lake. The layers of cement dip at about 20° to N.E., and on the south-west side rest on a denuded surface of mica-schist, forming a true bottom to the formation, which also dips N.E. at the same angle. The cement on the north-east side is cut off abruptly by a great fault dipping at 37° to W.S.W. A large area several acres in extent of the face of this fault has been laid bare. It is quite smooth, the schist being faced with 9in. to 12in. of hard splintery rock that passes insensibly into the schist, but presents a polished slickenside to the strata of cement which abut against it. This black rock, which in hand-specimens might be mistaken for a compact basalt, has the following composition:—

Silica	61·22
Alumina	10·13
Iron protoxide	15·81
Iron sesquioxide	Traces
Manganese	Traces
Lime	3·02
Magnesia	3·82
Water of constitution	4·27
Alkalies and loss	1·73
	100·00
Hygroscopic water	4·31

Hardness, 3. Fuses rather easily to a black bead, but is only slightly affected by hydrochloric acid.

It has thus a similar composition to the mica-schist, from which it has no doubt been derived as the result of pressure and motion due to the slipping along the fault. I understand that this black face has been traced in depth beyond the cement, and that it was found to continue, the upper wall being then formed of schist-rock. From these circumstances I infer that the source of the Tuapeka gold, like that of Parapara, is from an ancient alluvium a small area of which has become locked in a fault or slide that has gaped at the surface, and thus escaped the general denudation.

The gold was, if anything, found to be more abundant in the bottom layer of the cement, where it rested on the schist, but it occurs in every part of the cement. A rich gutter was always hoped for in the deepest ground of the supposed trough, but, obviously, could not exist if the cement has been faulted down, as the depression was formed after the cement was deposited.

I have attempted to estimate the average richness of the undisturbed cement, but the question has been so much complicated by results obtained from rewash gravels and from tailings that the results are not reliable, but it is probable that from top to bottom the average yield has been about ½dwt. per load. It is, of course, impossible to say how much of the cement was broken up by natural processes and redistributed to form the auriferous gravels of Gabriel Gully and Monro Gully; but about one-half of the cement hill or Blue Spur, as it existed in 1862, has been removed since that date by hydraulic sluicing and other processes, and a rough estimate gives the quantity still remaining undisturbed as about twenty million loads. For some years past the operations have declined, but in 1888 a company was formed in England for the purpose of consolidating the various Blue Spur claims, and working them as one property. The capital was fixed at £130,000, but only a portion of it was subscribed, and the company commenced operations at a great disadvantage, the working capital being wholly insufficient. Till December, 1890, the claims were worked spasmodically and with varying sucoess, the work being confined to sluicing the "tailings"—*i.e.*, ground that had already been washed over. These tailings produced on an average a grain of gold to the ton; but, as it was operated on by an elevator, and sluiced out at the rate of 60 tons an hour, the result obtained was generally sufficient to pay working-expenses and interest on the heavy mortgage debt which had been incurred at starting. In December last there was a new departure, the chairman of the company, Sir W. L. Buller, having succeeded in making a satisfactory rearrangement of the finances of the company, the result of which has been very gratifying.

During the first three weeks of the present year, working still in the tailings, the manager took from the sluice-boxes 793oz. 3dwt. 22gr. of gold, representing a value of £3,018 1s. 3d., which yielded a profit over working-expenses of nearly £2,000.

The returns for March represented a gross value of upwards of £1,500, and for the first half of May some £1,300 more.

Good results are anticipated as soon as the working parties reach the "cement" or virgin ground, the present operations which have yielded so good a result being confined to sluicing away the tailings in order to reach the face of the cement, and preparing a "paddock" in which to deposit the tailings from the undisturbed ground.

From the foregoing examples, it is evident that the systems of structural faults which intersect the country are deserving of attention on economic grounds; and a commencement has been made in the second part of Mr. McKay's report on the Amuri district, which will be found in this volume. In this paper he has attempted to trace the great fault-lines, and to indicate them on a map.

It must not be supposed, however, that the open faults and surface-rents that he so graphically describes are in any way peculiar to New Zealand. It is only that they have not been searched for in most other countries. The attention of geologists is now being turned in this direction, and especially in relation to the distribution and effects of earthquake-movements, which are now being generally recognised as connected with fault rendings rather than with deep-seated local explosions.

MAHARAHARA COPPER.

I re-examined the prospecting works at Maharahara, in the Ruahine Mountains, on the 19th March last, accompanied by Mr. Carter, who has been in charge since the last change of management.

The work which has been done since my former visit, on the 9th May, 1889, has been some further excavation in the upper level and the putting-in of a new level for 700ft. at 277ft. below the former level. Unfortunately, this new level, having been abandoned for about five months, has collapsed in several places, so that the water was dammed back to such an extent that I could not get more than half-way towards the face; but from the spoil-heap, with Mr. Carter's assistance, I was able to collect specimens for examination, and get a fair idea of the rock-formations which were cut through.

Tracings of the working plans which were furnished were also of great use in enabling me to form an opinion as to the value of the indications.

The new or low-level drive, when reduced to a bearing parallel with the upper drive, explores about 240ft. of new strata before reaching the first stratum cut in the mouth of the upper drive, and at 285ft. it intersects a vertical line below the upper drive, at 315ft. from its entrance and 25ft. from the face. The full length of the lower drive, owing to its slight obliquity to the strike of the strata, fails to explore the mineral ground by at least 60ft. less than was done in the higher level.

The rocks passed through in the low level are the same as those met with above—(*a*) indurated sandstones, (*b*) drossy slates, (*c*) red and blue chert.

At 600ft. from the entrance to the drive, what is described on the working plan as "boulder," containing iron and copper-pyrites, was cut. The vertical of this point would pass 15ft. east of the upper drive, and 75ft. north of the hæmatite and manganese lode, carrying copper, which was exposed by the cross-cut and winze in the upper drive, at G of my former plan, and which I supposed to be the same broken lode that showed in the outcrop winze. (Geol. Rep., 1888–89, p. xxiv. and plan.)

The dip of the supposed lode, as formerly deduced from the winze and upper-drive explorations, if carried through the lower drive, would intersect it about the point where this "boulder" was found, so that there was a fair presumption that it was the lode that had been intersected.

I was informed that soon after cutting this so-called "boulder" a strong rush of water was met with, and that at the same time all the higher workings, 270ft. distant in the vertical line, were rapidly drained.

If this information be correct, there can be no question that a true fissure has been encountered; and that it has a "tight foot-wall" is clearly proved by the large quantity of water which I found to be still discharging from the roof and walls of the drive before reaching the point where the fissure was intersected. It is therefore very disappointing to find that the "boulder" was never driven on in a systematic method: some portions of it were excavated, and these I collected from on the spoil-heap.

The term "boulder," I need hardly say, is obviously a misnomer, and it was probably intended to indicate an isolated segregated mass of rock. The specimens prove it to be the same siliceous hæmatite as No. 2 of my former report, and similar to the copper-bearing stone in the upper workings. It contains a considerable amount of pyrites, and four analyses gave the following percentages of copper: 1·6, 1·9, and 2·76 (Lab. Rep. No. 5,740).

The copper is only present in the form of chalcopyrites, neither carbonates, silicates, oxides, nor native copper being present, as in the outcrop specimens, which probably indicates that the lode is getting beyond the influence of surface decomposition. With regard to the ultimate success in the prospecting work that has been undertaken, it appears to me that nothing very definite has yet been ascertained.

The main incentive all along has no doubt been to discover the source from which the large blocks of rich sulphide ore found in the creek-bed were derived.

This does not appear to have been accomplished; but it must be remembered that what has been described as a low-level drive or tunnel is still more than 200ft. above the level of the creek where the good ore-blocks were found, and the deeper the ground the more likely it is to find this kind of ore. The prospects of the mine are therefore still purely speculative. My former recommendation was that any further work should be towards intersecting the lode at the lowest possible level accessible from the creek-bed, taking care that the tunnel is carried in solid formation.

The locality where such conditions exist would be in the spur rising from the Manga-atua Stream, or east of the present workings.

From all the information now obtained, the following points appear to be pretty well determined: (1.) That the country formation at Maharahara consists of submetamorphic sandstones and slate (probably of Triassic age). (2.) In this and in many other localities (*a*, source of the Pohangina; *b*, Manawatu Gorge; *c*, Otaki Gorge; *d*, Parapara Mine; *e*, Terawhiti; &c.) these strata have interbedded with them tufaceous or ash deposits, formed by contemporaneous volcanic eruption, and which contain various metallic ores. (3.) At Maharahara there are several such ash-beds which alternate with these strata, and they contain ores of copper, iron, and manganese. (4.) The strike of the strata in Copper Creek is about N. 70″ W., mag., and the dip is 60° to N.N.E. (5.) From the indications of outcrops, and from what has been exposed in the winze and tunnels, there is some evidence that the strata are cut by a fissure-lode, the direction of which is about N. 60° E., or across the line of bedding, and with an irregular dip to the north.

Had the new, or lower, tunnel been carried parallel to the upper this important point might have been determined; but, as it was carried on a converging bearing through the vertical of the old workings, it only proved the continuity of the fissure to the dip without disclosing its direction.

For the present I should not recommend the company to do more than some little work that is urgently needed to secure against the total wreck of the lower tunnel, and perhaps to spend a small sum on a cross-cut where the strong gush of water took place after intersecting the so-called copper-bearing "boulder."

To clear the timber from the spur towards the Manga-atua Creek would also be very useful in assisting the future tracing of outcrops, and selecting a point where a really low-level prospecting tunnel could be put in. In fact, if the gullies and hills in the immediate neighbourhood of the main valley could be cleared of timber the property would be much improved, as it would then be easy of access and open to inspection.

Considering the large sum spent by the company without any return I should think that a holding license might be granted to cover the period during which the property was being thus made accessible for further prospecting.

ENDEAVOUR INLET ANTIMONY-MINE.

On the occasion of my last visit to this mine I examined every part of it, but chiefly devoted my inspection to the structure of the country with the view of defining the ore-bearing belt. I find that for this further surveys will be necessary, as the evidence so far is somewhat contradictory; but there is no doubt that the mineral country lies in the junction-line of the Silurian and Devonian formations.

The eastern boundary is a yellow quartz-schist containing much iron-pyrites, which causes it to weather to a red colour, and so form a very characteristic soil, by which the mineral band can be traced. The richest ore has been found along this boundary, and it is probable that close to the junction of the formations the main lode must have its development.

The ore from the No. 1 tunnel, or high-level, and that which was found in the "slip" appears to be from the main lode; but the ore obtained in the other levels, so far as I have been able to determine, has been mined from irregular branch veins that are thrown off to the westward.

As in this direction the rock is hard and imperfectly mineralised, and is cut by irregular faults, the mining operations have from necessity been somewhat irregular, and have entailed a large proportion of "deadwork," so that the amount of rock excavated has been at least six times the quantity of ore that has been brought to "grass." This extra work has to some extent been rendered necessary by the form of the surface, which presents a bold spur bounded by deep ravines on the east side, but it has enormously increased the cost of the operations.

No. 1, at the summit, and the No. 6, or slip-tunnel, are the only openings that enter the actual ridge of the spur. Nos. 2, 3, 4, and 5 have been entered from the west ravine, no doubt with the view of saving expense in boring; but in each case the drives have been diverted to follow what must be considered as offsets or leaders from the true ore-band, and as a result the ore has had to be extracted in these levels from poor, irregular veins in very hard country.

The most promising and best-placed drive certainly is the No. 7, or slip-level, which is the only one that has been entered from the eastern ravine, and through the east wall, or back of the mineral belt. Unfortunately, this drive appears to have been discontinued after about 70ft., and before cutting the mineral ground. In fact, the workings up to the present time have disclosed very little information as to the mineral structure of the country rock, especially in the deeper levels; and I would strongly recommend that the No. 7 tunnel should be continued until it completely intersects the lode-belt that lies between the quartz-schist on the east and the feldspathic sandstone on the west.

The enormous masses of high-grade ore that have been found on the surface in the landslip that has slid from the level of No. 7 drive into the east ravine, proves that the main lode must crop out to the surface in that part of the property.

On the whole, I was very well satisfied with the progress of the mine, and feel sure that there is fair ground for expecting the ore-deposits to improve in the deeper levels and in the solid country.

Up to the present time, in most cases where the lode has been lost it has been due to a cross-fault or slide, which in some few cases is a structural feature, but in most is due to surface movements. The picking-up of the lode beyond such faults involves expense and trouble, but does not present any insuperable difficulty to scientific mining.

The specimens I brought for analysis from the various levels have given a satisfactory return, varying from 15 to 75 per cent. of antimony-sulphide.

OKAIHAU.

An application was made for a further survey of the "ironstone" deposit at Okaihau, in the Bay of Islands District.

The indications were not sufficient to warrant the expense of a special examination, the structure of the district being well known, as will be understood from the following notes.

The iron-ore at Okaihau occurs in the form of limonite, or compact bog-iron ore, containing from 60 to 85 per cent. of iron-oxide, or equal to about 50 per cent. of metallic iron. The position of the deposit is about one mile north of the Omapere Lake. The country here is formed of a lava plateau, the volcanic rock being of a description that contains much iron. The lava plateau terminates to the westward in a steep slope to the Hokianga watershed, and in this direction the lava-streams are seen to rest on the surface of the plastic-clay formation, which contains seams of lignite. The iron has probably been derived from chalybeate springs discharging into a large swamp; but, in the form of small nodules and concretions in the surface-clays, ironstone is scattered all over the Kirikiri and Waimate table-land to such an extent as to render the soil almost worthless. North of Mr. Nicholson's house, in the scarp of the plateau, there is also a deposit of siliceous sinter, marking the former action of hot springs at this place. Siliceous and ferruginous sinter is also met with at the eastern limit of the lava plateau near Pakaraka. In superficial appearance these deposits resemble the gossan of the Mount Morgan deposit, in Queensland.

Gold has been reported by Mr. Pond in this ferruginous rock, but none of the samples examined in this laboratory have proved to be auriferous.

As an iron-ore this particular deposit at Okaihau, under the circumstances of its occurrence, far removed from fuel and from a shipping-port, is not likely to be of any other use than for the purpose of manufacturing hæmatite paint, as is done with exactly the same kind of stone at Kamo, Thames, Parapara, and other places in the colony. The thickness of the deposit has not been ascertained, but in 1888 it was quarried to a depth of 5ft. for road-metal and was quite solid. Its extent is about 100 acres, so that there are probably a million tons available.

GOLDEN BAR REEF.

The outcrop of the reef in the Golden Bar lease is situated in the Wakamarina Valley, three miles from Deep Creek Township, and is on the northern side of Dead Horse Gully, at an elevation of 700ft. above sea-level. This district was examined by myself some years ago, and again during the past season by Mr. McKay, who supplied notes on the present state of the workings.

At the outcrop the reef strikes E.S.E. and W.N.W. (123° mag.), and dips to the northward at angles varying from 70° to 80°. The average thickness of the lode is between 4ft. 6in. and 6ft. At the surface it has been traced continuously for a distance of 500ft., and on the same line outcrops of quartz indicating the presence of the lode have been found about a mile apart.

The character of the quartz is compact, white, veined at frequent intervals by dark streaks and partings. Pyrites is present, but not very abundantly, in the stone. Lamination of the quartz and the prevalence of the dark-streaked stone is chiefly towards the hanging-wall, but is also pronounced towards the foot-wall, and least so in the middle of the reef. Oxidation of the sulphides contained slightly modifies these characters at the outcrop.

In the upper tunnel, 710ft. above the sea-level, and 80ft. below the outcrop, the original and true character of the quartz is finely shown. From the outer end of the tunnel the reef was cut at a distance of about 80ft., and to the right and left it has been driven on for a distance of 210ft., and the stone taken from the 6ft. by 6ft. drive for that distance is said to be equal to 400 tons. Towards the east end of the cross-drive, following the line of stone, a winze has been sunk 12ft., at the bottom of which the reef shows a thickness scarcely less, and has a promising look, being veined in the manner described.

The lower tunnel enters at 600ft., or 110ft. below the level of the upper. The distance driven to intersect the reef is about 150ft.

The reef has been cut, and the hanging-wall reached, and there is showing a thickness of 6ft. of quartz of the same character as that seen in the upper drive. Yellow pyrites, in cubes, occurs as narrow strings in some parts of the stone, and the joints contain grey pyrites, but not in large quantities.

Nine or ten samples of the stone from both drives, calcined, and just as they came from the mine, were crushed and panned off by Mr. McKay, and all of them showed the presence of gold, and in such quantity that if such yields were obtained by battery work the reef will pay to work. In none of these tests were the results to be absolutely relied upon; so, to secure a check on the results, samples taken from both the bottom of the winze in the upper level, and from the middle and upper third of the lode in the lower level, were forwarded for analysis.

Adjoining the Golden Bar, and to the east-south-east, is the Duchess of Albany Claim, in which a tunnel is now being driven to intersect the lode, which it will do after driving a further 10ft. The drive on this claim is on the same side of the creek as those in the Golden Bar ground, and, although the reef has not been seen *in sitû*, there need be no hesitation in pushing on the work, which will cut the reef at 30ft. below the level of the lower tunnel in the Golden Bar lease.

Further to the south-east, on the opposite side of the valley, quartz-leaders are found, and gold in the surface-soil and subsoils; but as yet the main body of stone has not been found.

Mr. McKay was impressed by the size and continuity of the reef (only at one place is it less than 1ft. thick) and by the general similarity of the stone to that in the Keep It Dark Mine, Reefton, and so far the tests made lead to the belief that the mine will pay; and if the reef can be cut 180ft. below the present lower level, it will give such a quantity of backs level-free as would warrant a considerable expenditure of capital.

BULLER COALFIELD.

The general structure of this important coalfield has been frequently reported on, but during the past year an important exploration was made by Mr. McKay of the northern portion, where it is intersected by the Mokihinui River. It is somewhat remarkable that, within the great area between this and the Buller River and west of the valley of Orekaka Creek, there are no beds representing the Cobden limestone and the higher calcareous members of the Cretaceo-tertiary series; but, because these calcareous rocks, or their representatives, are not now present, it must not be contended that they never spread over the area in question, nor that the rocks in question belong to different formations, and have no connection with the marls and sandstones, grits, and conglomerates that constitute the coal-bearing series in the special and more restricted sense of the term.

Immediately outside the limits of this area, to the north-east and south, the formation is complete and the sequence perfect as far as the upper surface of the Cobden limestone. To the north and north-east the formation extends, though not continuously, on the one hand into the extremity of the Collingwood district, and on the other into the watershed of the Motueka River, in which directions the quality of the coal so differs from that of the typical coals of the West Coast fields that these differences have been considered by some geologists as sufficient reason for regarding the formation in these distantly-separated localities as belonging to a different geological period. Comparing similarly the bituminous coals of the west coast of the South Island with those found on the east coast, in Otago, or on the west coast of the North Island, the difference in the quality of the coal is equally marked. To the coalowner and practical miner it may be a matter of little consequence of what geological age the coal may be, provided it is of good quality and the seam has a sufficient thickness, and is so situated as to enable it to be profitably worked. If the roof be good and the cover sufficient the geological age of the bulk of the overlying strata is naturally regarded as of little moment.

Within a limited area and over a well-explored coalfield this may be a proper view of the case, but where several detached coal-areas in the same region require to be prospected the nature of the covering formations is of importance, and it becomes necessary to discriminate strata which belong to the coal-bearing sequence from those that belong to unconformably younger formations.

In the case of the Mokihinui Coalfield the rocks to the north-east and south of the river below the second gorge are not the same. To the south of the river there are conglomerates, grits, sandstones, and shales, associated with coal-seams, the highest bed of the series being a dark-blue mudstone containing calcareous ironstones. Such strata are never found underlying a coal-seam, but they form the roof of the 32ft. seam in Coal Creek. To the north of the river, except over a limited area opposite the junction of Chasm Creek, the grits, sandstones, and shales of the coal-measures are unknown; but in this direction there is between the coast range and the second or inland range of crystalline rocks a great development of the dark, marly, or mudstone beds that overlie the big seam in Coal Creek, and these are also developed along the eastern side and in the southern part of the coalfield. These marly rocks are followed by limestones resembling and probably of the same age as the Cobden limestones at Greymouth; and the question, apart from the depth at which it may occur, is whether or not the coal is present under the limestone and marls in the area north of the Mokihinui River.

Near the mouth of Chasm Creek the coal and overlying sandstones are seen to dip under the marly strata to the north of the river, and these in turn to pass under the limestones.

The limestones and underlying marly beds have generally been considered to belong to the same age and formation as the coal itself; but, if it were to be proved that unconformity does actually exist, it should be found not merely within the Mokihinui Coalfield, but over the whole of the West Coast from Collingwood to Greymouth, and at very many places it would then be reasonable to expect that the coal may have been removed by denudation before the deposit of the lowest members of the overlying and unconformable formation. If this were the case it would tend to reduce the prospects of the western coalfields, as there could no longer be any assurance of the coal-measures extending under the marine marls and limestone.

In the "Transactions of the New Zealand Institute" (Vol. xxii., 1889, p. 377), there is a paper on the relative ages of the New Zealand coalfields, by Professor Hutton. I will not discuss that paper in all its bearings at present; but, as Professor Hutton himself says that the question as to the identity and conformity of the limestones which by the Geological Survey Department is supposed to close the coal-bearing sequence "is of great economic importance, and likely to interest persons who are not professional geologists," this and the more special reason in regard to the northern extension of the Mokihinui Coalfield makes it necessary to examine a few of his alleged facts, and to consider carefully the conclusions to which they have led and may yet lead us. Professor Hutton inclines to discredit stratigraphical and lithological evidence, and to rely altogether on the palæontological records, and, by adopting the same age for the underlying coal as that indicated by the marine fossils found in the overlying strata, he classifies the New Zealand coalfields as belonging to four different geological periods.

But against this view it must be pointed out that no marine fossils have ever been found passing down into the coal-bearing beds, and that in no part of the Islands has coal been found excepting in the bottom beds of the series and in lacustrine or fluviatile deposits, which rest on a denuded land-surface of more ancient rocks, and that, with a few exceptions, we find no reversion to carbonaceous beds above the marine strata in any part of New Zealand until we reach the close of the Miocene period.

Professor Hutton correlates the western coal-formation on the strength of two fossils—*Cardium brunneri* and *Kleinia disjuncta*—which have been in the Colonial Museum at Wellington since 1872; but he appears not to be acquainted with the other associated species, of which both in the Greymouth and Buller fields there is no scarcity.

I do not here refer to the fossils of the Cobden limestone, or even of the marly strata that directly underlie the limestone, but to the fossiliferous beds that closely overlie the coal at Brunnerton; at the Nine-mile and Ten-mile Creeks, north of the Grey River, in the Greymouth field; and at Welshman's Terrace, Brighton, Cape Foulwind, and other places on the coast south of the Buller River; also near the old Wellington Mine, Ngakawau River, at the source of the Ngakawau and between that and Chasm Creek in the Mokihinui Coalfield; and again in the Inangahua Valley, at the junction of the Inangahua with the Buller, and in the neighbourhood of Reefton. Nor is there any lack of fossils from the beds over and directly associated with the coal at the Baton, in the Motueka Valley, or in the Collingwood district, in the north-west of Nelson.

He also accepts the determination of the fossil flora by Baron von Ettingshausen, who pronounces it to be different from and older than that from the Waipara and Shag Point, being, he thinks, of Cretaceous age; but Professor Hutton must be very well aware that the Baron regards the flora of the Waipara and Shag Point beds as of Tertiary age, while at the same time he himself has pronounced the age of the beds in question to be Cretaceous, which they undoubtedly are. There is abundant and unquestionable proof of the Cretaceous age of these beds if Belemnites, Inoceramus, and Plesiosaurian remains can be accepted in evidence. These fossils have been found in the Waipara beds of the Middle Waipara, North Canterbury; and there is, both there and at Shag Point, a fauna largely identical with that at Amuri Bluff, the beds at which latter place have always been regarded as of undoubtedly Cretaceous age. In this matter of the age of the Waipara and Shag Point beds, Baron von Ettingshausen must therefore be considered as being in error; and, even if the flora of the West Coast coalfields is different and of older date, the evidence of the fossil fauna, if employed in the argument, would indicate that it is younger.

Professor Hutton considers that the Oamaru series (Upper Eocene) overlies these western coal-measures probably unconformably, without the intervention of any rocks with the Waipara fauna and flora: but in this connection has to be considered the age of the brown and pitch-coals of the Nine-mile Bluff, north of Greymouth; of Welshman's Terrace, on the Fox River; of Reefton and the Upper Buller Valley; of the Baton River; and of West Wanganui Inlet, in the Collingwood district. No fossil flora has been collected from them, and it might be asked if these belong to the same series as the bituminous coals of the Grey or Buller fields, or to the Waipara or Oamaru series.

The Geological Survey finds no difficulty in answering this question, but it is not likely to prove so easy to those who hold the views advocated by Professor Hutton, unless by making very short work of the stratigraphical evidence that has been accumulated.

Professor Hutton's conclusion is that the New Zealand coalfields may be grouped by age as follows: 4. Coalfields belonging to the Pareora series—(*a*) Mokau; (*b*) Waihao; (*c*) Waitaki; (*d*) Pomahaka; (*e*) Dunstan (?). 3. Coalfields belonging to the Oamaru series—(*a*) Bay of Islands; (*b*) Whangarei; (*c*) Drury and Lower Waikato; (*d*) Nelson and Motupipi; (*e*) Kakahu; (*f*) Green Island and Saddle Hill; (*g*) Tokomairiro and Kaitangata; (*h*) Nightcaps, Moreley Creek, and Linton; (*i*) Orepuki. 2. Coalfields belonging to the Waipara series—(*a*) Malvern Hills; (*b*) Mount Somers; (*c*) Shag Point; (*d*) Mount Hamilton. 1. Coalfields belonging to the Amuri series (?)—(*a*) Pakawau; (*b*) Wangapeka; (*c*) Westport; (*d*) Greymouth; (*e*) Reefton.

This arrangement appears to me to be somewhat arbitrary, and it might be inquired on what grounds are the Waihao and Waitaki coals included as belonging to and part of the Pareora series. Most of the readers of the Geological Reports are likely to come to the conclusion that, if they are not of Cretaceo-tertiary age, at the very least the coals at these places should be referred to the Oamaru series of Hutton. Professor Hutton admits that where no inversion or telescoping of strata has taken place vertical superposition is a positive proof of the younger age of the uppermost or overlying beds, and at the Waihao and in the Waitaki Valley (excluding the Wharekuri coal, which may belong to the Pareora series) there can be no possible mistake as to the superior position over the coal of the limestones belonging to the Oamaru formation of Hutton. Again, what can be the reason for placing the coal-beds of the Kakahu with those belonging to the Oamaru series, those of the Waihao being referred to the Pareora series? The proof of their inferior position in relation to the neighbouring Oamaru limestone is beyond doubt.

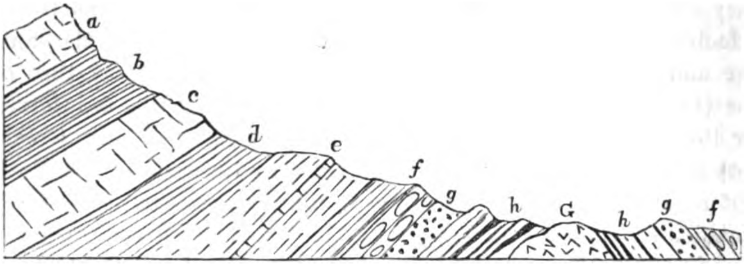
The question is thus raised both as to the conformability of the mudstone and dark marly beds that cover the big seam in Coal Creek, and which are present over the eastern and southern parts of the field, and the following conformity of the beds succeeding the limestone on the north side of the river. These contain a fossil fauna of Tertiary aspect, and as yet have yielded none of the characteristically Secondary forms that on the east coast of the South Island distinguish the beds of the Waipara series.

In the Greymouth district the sections from Brunnerton to Greymouth, and from the Ten-mile Creek to Point Elizabeth, and again in a line between the Buckland Mountains and the Buller Gorge, show a complete sequence of the Cretaceo-tertiary beds as developed on the West Coast. The highest beds of the complete sequence—the Grey Marls—are represented by the nummulitic limestone of Greymouth; and the Amuri limestone, though not developed in a characteristic manner, is represented by light-coloured marls. The basement beds present consist of coarse conglomerates (best seen in the Ten-mile Creek), followed by gritty sandstones and dark or grey micaceous shales, again succeeded by sandstones, these constituting the coal-measures.

At Coal Creek, at the Nine-mile Bluff, and in the Ten-mile Creek the highest seams of coal are of a non-bituminous character, and are classed as pitch-brown coals; but no one has ventured to assert that the beds containing these present a marked degree of unconformity to the lower strata containing seams of bituminous coal. Overlying the pitch-coal horizon are the "Island sandstone" and micaceous shales and dark marly fucoidal greensands which on the banks of the Grey River yield the fossils mentioned by Professor Hutton as being all that are known to him as coming from the Cretaceous coal-measures of the West Coast. These same beds form the strata immediately over the burning coal (brown coal) of the Ten-mile Creek, and also overlie the coal in the Nine-mile Bluff. Along the banks of the Grey River, between these fossiliferous beds and the black marls under the Cobden limestone, the section is not very clear; but it can be followed in the hills to the south of the river, and generally it has been considered that there is no evidence of unconformity. In the section from the Nine-mile Bluff to Point Elizabeth no unconformity can be detected between the fossiliferous beds over the coal (of Cretaceous age, according to Hutton) and the Cobden limestone at Point Elizabeth. So far, therefore, it appears, although it may not be definitely proved, that all the beds in this field, from the Brunner coal to the Cobden limestone, are in unbroken sequence with each other.

At Reefton, where the coal (according to Hutton) is of Cretaceous age, there are, strictly speaking, no bituminous coals present, their physical characteristics and chemical composition proving them to be pitch-coals. With one exception, they are non-caking. The coal on the Ajax Claim frits and forms a feeble incoherent coke. Can these be regarded as of the same age and occupying approximately the same horizon as that of the Grey and Buller bituminous coals? Clearly this is inferred by Professor Hutton. There are here also, at Rainy Creek, fossiliferous beds resting immediately over the roof of the coal, but none of the higher beds of the sequence, as seen in the Grey Coalfield. As the fossils are the same as those found over the coal in the section between the Brunner Mine and the Cobden limestone at Greymouth, and at the Nine-mile Bluff and Ten-mile Creek, these Reefton fossils must also be of Cretaceous age.

Along the west side of the Inangahua Valley there is a great development of the higher part of the sequence, below which lie the coal-measures, rising high on to the Paparoa Mountains. At the junction of the Inangahua the quartz grits and conglomerates are wanting, and the lower fossiliferous beds rest on the Maitai slates at that place, as proved by lithological characters and the presence of the Mount Torlesse annelid. But lower down the Buller Valley a full development of the sequence, continued north from the eastern slopes of the Paparoa Mountains, reaches and crosses the Buller River, and, extending along the valley of Orekaka Creek by way of Cedar Creek and the Upper Ngakawau, directly connects with the Mount Rochfort and Mount Frederic areas of the Buller Coalfields, and also from the Upper Ngakawau to the Mokihinui Coalfield. On the west slope of Mount Rochefort Plateau, to the east slope of Mount Frederic, between Crane's Cliff and the sea; and from the Middle and Upper Ngakawau, extending, as already described, over the southern and eastern parts of the Mokihinui Coalfield, are the dark mudstone and marly strata of marine origin, and containing the same fossils that succeed the coal-measures at Brunnerton. In the Upper Mokihinui and Karamea valleys, and between the Karamea and Collingwood, the fossiliferous beds everywhere when present follow the coal conformably, and are never found resting on the older rocks as outliers and detached masses; so that in this rugged country the coal series is exposed at nearly every altitude from the sea-level to 6,000ft. The unity of the sequence may be illustrated by the following section, which represents 2,700ft. in vertical height:—

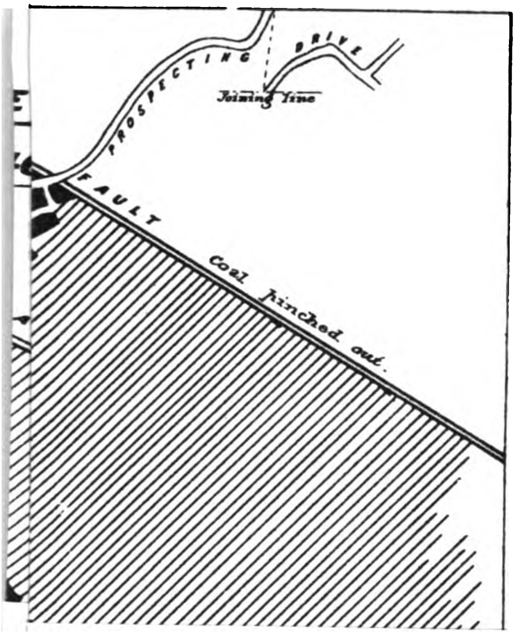


Section at source of Karamea River. *a.* Grey concretionary limestone. *b.* Grey marls, with *Pecten pleuronectes*. *c.* White, splintery limestone. *d.* Fucoidal greensand. *e.* Chalk-marls, with bands of chert. *f.* Dark greensand and concretionary sandstone. *g.* Brown grit and sandstone, with *Cardium brunneri*. *h.* Brown sandstone, with fossil plants and coal-seams. G. Granite.

Sometimes, owing to the non-development of the coal-measures, as for instance on the Mount Arthur table-land, and at the junction of the Inangahua with the Buller, the marine beds are seen to overlap and rest direct on the old rocks. In other parts of the same area, where coal-measures and coal-seams are developed, these invariably underlie the fossiliferous part of the sequence conformably, and the proofs are complete that all belong to one and the same formation.

The evidence in the Upper Buller Valley confirms this view of the unity of the sequence, and therefore the uncertainty as to whether the coal-measures underlie the marly and higher beds need not cause apprehension.

On Mount Rochfort Plateau the coal is often absent from areas over which there is a considerable thickness of the measures, and when it is considered that the coal is at most places lying hard on the old rock (Maitai formation) it will be apparent that over such barren areas it never has been deposited. No doubt such areas without coal may also occur in the Mokihinui field, and might occur in those parts over which the mudstone and marl formation is at the surface, but this absence of the coal should not be referred to the action of denudation prior to the deposit of the beds actually present. Hence it will be seen that, subject to the existence and probable presence of such barren patches, the same productive coal-measures of the southern part of the coalfield extend north of the Mokihinui River, and, with the exception of the greater depth to which it will be required to sink in order to reach it, the conditions under which the coal may be found are not likely to be geologically



(a.) 1886-87, pp. xlv.-li.

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ay be found are not likely to be geologically different for many miles north of the Mokihinui River from those of the Mount Rochfort plateau.

NORTH-WEST OTAGO.

The geology of the district north of Milford Sound has attracted attention of late years since the discovery made by Mr. Skey, among specimens sent for analysis, of a nickel-iron alloy (awaruite) allied in its composition to meteoric iron. An article by Professor Ulrich, of Dunedin, which appears in a recent number of the Journal of the Geological Society of London (Quart. Jour. 1890, p. 619), deals with this subject, and, among other things, describes the geology of the district and gives a geological map. Strangely, he has omitted all reference to the reports of the Geological Department which deal with the same matter,* and, without having himself seen the country, but relying on hearsay information, has introduced changes that are incorrect. I therefore feel it a duty to recapitulate the chief points which have been recorded concerning the geology of this interesting district.

Between Jackson's and Martin's Bays the country to the west of the main range of mountains forming the water-parting between the east and west coasts of this part of the South Island consists of a parallel range of lesser height, the western slopes of which merge into a broken hilly country descending to the coast-line, which is formed of several bays separated by bold

* List of papers and reports dealing with the south of Westland and north-west Otago:—

1. Narrative of an Expedition to the West Coast of Otago in the "Matilda Hayes." By Dr. Hector, *Otago Provincial Government Gazette*, 5th November, 1863.
2. Hector on the Coast from Milford Sound to Hokitika. (Geol. Rep. 1866-67, p. 42.)
3. Report on the Geology of Otago. By Professor F. W. Hutton, F.G.S., Dunedin, 1875.
4. Report on Coal-measures at Jackson's Bay. By S. Herbert Cox, F.G.S., F.C.S.
5. Reports of Geological Explorations, New Zealand. (Geol. Rep. 1874-76, p. 96.)
6. Notes on the Geology of Jackson and Cascade Valleys. By D. MacFarlane, Government Resident Agent, Jackson's Bay, with a Memorandum on the Rocks and Specimens collected by Dr. Hector. (Geol. Rep. 1876-77, p. 27.)
7. On the Wakatipu and Greenstone District. By S. Herbert Cox, Assistant Geologist. (Geol. Rep. 1878-79, p. 53.)
8. On the District West and North of Lake Wakatipu. By Alexander McKay, F.G.S. (Geol. Rep. 1879-80, p. 118.)
9. On the District between the Dart and Big Bay. By James Park, F.G.S. (Geol. Rep. 1886-87, p. 121.)
10. Progress Reports. By the Director of the Geological Department:—(*a*.) 1874-76, p. xi.; (*b*.) 1878-79, pp. 25, 26; (*c*.) 1879-80, pp. xxvii.-xxx.; (*d*.) 1886-87, pp. xlv.-li.

headlands, plateaux, or high terrace-lands descending abruptly to the coast-line.

The north-eastern higher flanking mountains form the Red Mountain and Olivine Ranges, and to the south merge into the Bryneira Mountains, the Lake Harris Range, and the Alsia Mountains. In this latter part of the district, however, these mountains do not reach the coast-line, but to the west are bounded by the Hollyford Valley, between which and the sounds of the west coast rise the Darran Mountains, reaching far above the line of perpetual snow. The drainage of the northern part is carried principally by the Cascade River and the Pyke River, a tributary of the Hollyford; and further to the south by numerous small streams, tributaries of the Upper Hollyford.

The Hollyford or Kakapo Valley runs along the line of a great synclinal fracture which from Foveaux Strait follows the eastern base of the crystalline mountains of Western Otago. This great fault-line has its downthrow on the eastern side, and on that side brings fossiliferous and unaltered Permian and Carboniferous formations in contact with the crystalline rocks on the west side of the fault. North of Martin's Bay the fault runs out to sea, and the younger rocks on the downthrow side constitute the coast-line as far as Jackson's Head. The Hollyford River flows along this great fissure to the junction of the Pyke, and the direct line is thence continued to the east of the Skipper's Range and Lake McKerrow to the upper part of Awarua or Big Bay. In a direct line it would be so continued, but probably at this point it bends more to the west, and, following the course of the Hollyford, runs out to sea at Martin's Bay, resting on the crystalline schists forming the western wing of the great central anticline running through interior Otago. From the crystalline schists the unaltered rocks dip to the east, or away from the crystalline schists of Skipper's Range and the Darran Mountains; and, according to the sections given by Park, the contact with the schists of the eastern mountains is by a fault, along which the magnesian rocks appear as eruptive masses. The great fault itself being of comparatively modern date, involving as it does at several places Cretaceo-tertiary and probably even Miocene Tertiary rocks, it will not be surprising that there are evidences of several of the drainage-channels being of a date subsequent to the formation of the fault-line.*

* For further details as to the physical configuration of the district see Reports Nos. 7 and 8 of the list given above.

The formations present in the district are as follow:—

I. *Recent*, consisting of alluvial flats, swamps, river-beds, glacier-deposits, and high-level terraces.

VI. *Cretaceo-tertiary*, consisting of slaty clays, green-sands, conglomerates, and limestones.

XII. *Carboniferous*, formed of (*a*) Maitai series—Green, blue, and grey slates, and grey limestones.

XIII. *Upper Devonian*, embracing—(*a*) Te Anau series, aphanite-sandstones, breccias, &c.; (*b*) Kakanui series, composed of grey micaceous sandstones, blue slates, &c.

XVI. *Foliated Schists*, including—(*a*) Upper—green schists, mica-schists, with thin-bedded grey pyritous quartz; and (*b*) Middle—soft blue mica-schist, interlaminated with quartz and green schists.

XVII. *Crystalline Schists*.—Grey pyritous rock, eruptive rocks, dunites, serpentines, syenites, intersecting gneissic rock and granites. (Geol. Rep. 1886-87, p. 129.)

I. *Recent*.—This series of accumulations is of interest chiefly on account of the auriferous character of some of the deposits, and on account of the presence of *Awaruite* in the alluvia of some of the river-valleys. These are fully described in Mr. Park's report, so far as his mapping extends to the north-east.

Describing the high land terraces, he says, "The material composing them consists of weatherworn wash, mixed with a large number of rounded boulders of aphanite-sandstone and breccia-dunites and many varieties of syenite rocks, a large number of the boulders exceeding 10ft. in diameter. On close examination the rocks forming the terraces are found to be foreign to the coast. All the large boulders, with the exception of the dunite, consist of rocks that belong to the Te Anau series, which does not occur *in situ* nearer than the back ranges at the sources of the Pyke, Gorge, and Hope Rivers, where this formation is largely intruded by massive dykes of syenite. But Awarua River does not extend back to this area, and is therefore incompetent to have brought down the material forming the terraces on the shores of Big Bay. This at once discloses the fact that this river must at one time have had its source in the Red Mountain, and this is obviously the case, as the large swampy flat which exists between the upper source of this river and the Pyke does not exceed 100ft.

above the sea at the present time, and when standing on any elevated position the impression conveyed to the mind from the general lie of the country is that the Awarua still drains the Red Mountain area."

Further to the north, at Cascade Point, and thence extending east to near the bend of the Cascade River, Mr. MacFarlane describes similar gravel-conglomerates as follows: "About a mile below the Cascade Saddle the left-hand branch enters a gorge about two miles long. The river being very low I managed to pass down through the gorge. The river having cut clear through to a depth of 150ft. in places, a fine section of the formation is presented, which consists of a heavy conglomerate, showing very complete stratification, having a slight dip to the north-west. This formation continues right down to the sea, unless where cut through by the streams, and forms the Cascade Plateau.* The river has cut clear through the conglomerates, exposing the older slates beneath, marked A (micaceous sandstone),† and upon which the conglomerates are lying unconformably, the slates dipping to the north-west, at an angle of 36°. At Tier's Creek, on the coast-line, at high-water mark, the underlying rock is exposed, consisting of blue clay passing into rock. Where this immense body of cemented wash has come from, and the process by which it has been so evenly distributed, is more a question for experts to deal with than for me to guess at; but, aside from all geological speculations as to the 'whence and how' of such things, I think a thorough examination of the country indicated would be productive of useful results."

VI. *Cretaceo-tertiary*.—The existence of calcareous sandstones overlying greensands with coal was first discovered at the south head of Martin's Bay by myself in 1863. At this place they occupy only a small area, and are steeply inclined.

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* This gravel plateau is well known, and in passing along the coast the character of the rocks forming the Cascade Plateau cannot readily be mistaken. Yet, strangely, the whole of this area on the geological sketch-map by R. Paulin, which illustrates Professor Ulrich's paper, at page 624 of the Quarterly Journal of the Geological Society, 1890, is shown as being occupied by serpentine and olivine rocks. Further, in other respects this map may be assumed to be incorrect, since it agrees badly with those published by MacFarlane and Park, who show a very different distribution and extent of these rocks. It is unfortunate for Professor Ulrich that he seems to have overlooked the geological maps of the district which had been published long before his paper was written.

† It will be seen by reference to Mr. MacFarlane's report on the Geology of the Jackson and Cascade Valleys that he did not attempt to name the rock-formations. Specimens of these obtained during his exploration of the district, distinguished by numbers, as corresponding with the sketch-map, were forwarded to the Geological Survey Office, and their nature was determined by myself.

Again, between Cascade Point and Jackson's Head the same beds were found by me in 1866, and were again examined by Mr. Cox during 1876; and, although in that district the formation is of great extent, the principal economic product of the formation—coal—appears to be absent, or occurs only in thin, unworkable seams.

XII. *Carboniferous*.—(*a*.) Maitai Series.—This formation is of interest from its being in contact with magnesian rocks, serpentine and olivine (peridotite), along the greater part of the eastern boundary which is formed by the upper schists, the only exception to this being the northern part of the Bryneira Range. Still further to the north, on the east side of the olivine belt, as it has been termed, older mica-schists like those of the Otago goldfields are in contact with the same magnesian rocks.

More to the south, along the west side of the Lake Harris Range, in 1871, I found on the west side of the serpentine belt an inverted series of dark-coloured argillaceous sandstones, containing Permian fossils like those found south of Nugget Point. According to McKay the grey flaggy limestones which underlie these correspond to the Maitai limestone, but possibly it may be the Shaw's Bay limestone which underlies the beds to which I refer.

XIII.—(*a*.) The Te Anau series, which has its typical development a few miles to the south, in the valley of the Greenstone River, is everywhere difficult to separate clearly from the preceding series. Between Lake Gunn and the Greenstone the aphanites are in contact with impure marble. (*b*.) The Kakanui or Walter and Cecil Peak series, being semi-metamorphosed, is more readily distinguishable, and Mr. Park was able to determine the boundaries over considerable areas of these formations to the north and south of Big Bay.

XVI. *Foliated Schists*.—(*a*) Upper, and (*b*) Middle: These are found only to the east of the serpentine and olivine belt, and on that side make contact with the ultra-basic rock wherever they make their appearance.

XVII. *Crystalline Schists as mapped by Mr. Park*.—Serpentine, olivines, and associated rocks: Of these, the descriptions given by MacFarlane and Park may fairly supplement the technical determinations of Professor Ulrich.

Mr. Surveyor Park says the rocks coming under this head are principally dunite and serpentine, with which are associated nephrite or greenstone, hypersthene, bronzite, steatite, asbestos, chrysolite, picrolite, and chrome; and he adds, "The dunite forms by far the greater mass of the Red Mountain, and of all the areas occupied by these rocks, the serpentine occurring only as large vertical dykes, and the other minerals enumerated above as veins or reefs." Mr. Park considers the whole to be of an eruptive character, and with them includes the syenites of the Te Anau series, under the head of eruptive rocks, but without indicating the period of eruption.

On this point Professor Ulrich says, "With regard to the geological relations of the peridotic and serpentine rocks to the enclosing crystalline schists, there can be no doubt, according to Messrs. Henderson and Butement's observations, that the former are intrusive through the latter, several places having been observed by them where the strike of the schist was right against the peridotic and serpentine outcrops." (Quart. Journ. Geol. Soc., Vol. xlvi., p. 621.)

I fear that this is not distinct evidence of the intrusive character of the rocks in question, more especially when it had already been shown that the rocks on both sides of the magnesian belt are not of the same age and character. My knowledge of the same formation in other parts of New Zealand, and McKay's work in this district in 1880, has led to a different conclusion respecting the mode of occurrence and the relations of the serpentine rocks, and there is every reason to believe that the serpentines are the altered products of contemporaneous eruptions, occupying definite horizons, either in the Te Anau series or between that and the lower members of the Maitai series. The relation of these rocks was described by McKay as follows: "West of Lake Wakatipu, wherever Te Anau and Maitai rocks are developed, serpentines are sure to make their appearance along the boundary between the two formations, or between these and the older formations with which they are in contact. From the northern boundary of the district examined west of the main range the serpentines are continuous along the valley of Hidden Falls Creek to the north, and of the Lake Harris Range, and then along the western slopes of that range to the Hollyford Valley, at the foot of the Greenstone Pass. This line of serpentinous rocks is generally less than a quarter of a mile wide, and frequently not more than 300ft. or 400ft. In breadth it appears to increase as it is followed to the north."

Over that part of the magnesian belt which has been examined the principal rock is a dark-green, almost black, serpentine, but not unfrequently light-grey talcose and asbestosine rocks are present. Grey felsite rocks are abundant as massive developments, but are seldom continuous in dyke-like lines. Hypersthene and bronzite occur, although not plentiful, in the southern end of the belt. Chrome-iron occurs in the north end of Lake Harris Range, but no indications of copper were detected. Generally along this western line sulphides are remarkably rare.

To the presence of this line of serpentines is partly due the remarkably abrupt and rugged character of the western slopes of the Lake Harris Range. The serpentine accurately marks and forms the separation-line between the unaltered rocks and the schistose rocks lying to the east, and, where it occurs, the limestone closing the Te Anau series, or forming the lowest member of the Maitai series, is always in the near vicinity of, or in close contact with, the serpentine belt. Along the eastern side of that part of the district covered by the Te Anau and Maitai rocks serpentines are also developed, but appear to be more closely connected with the Te Anau than with the Maitai series. The serpentine bands extend along the junction of the partly-metamorphosed Kakanui series from the saddle between the Route and Rock Burns along the higher and western part of the Humboldt Mountains, across the Greenstone Valley at the back of Tooth Peak, and thence along the Thomson Mountains to beyond the boundaries of the district.

Professor Ulrich incorrectly describes the southern continuation of what he terms the Red Hill* peridotic and serpentine belt. He says, "From Red Hill, the rocks, however, doubtless extend (probably with interruptions, and, for certain, much contracted in width) much farther southward, even beyond the point Mr. Müller mentions near the Humboldt Mountains, six miles and a half west from the junction of the Barnes Creek with the Pyke River). What leads to this conclusion is that Messrs. Henderson and Butement saw conspicuously bare and red-coloured mountains and ridges (like those of the Red Hill Range) further southward, near Lake Harris saddle, the watershed between the Route Burn (a tributary of the Dart River falling into Lake Wakatipu) and the Hollyford River; and they found boulders of olivine rock and serpentine in one of the creeks rising near that saddle and falling into the Hollyford River." (Quart. Jour. Geol. Soc., 1890, p. 625.)

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* This should be "Red Mountain," as named by myself in 1863. Red Hill is a different mineral locality, near Collingwood.

This is difficult to understand, as south-west of High Falls Creek the serpentine belt is confined to bush-clad country till near the Greenstone track, so that Messrs. Henderson and Butement must have been mistaken as to the rocks forming conspicuously bare and red-coloured mountains and ridges. Above the bush all the rocks on this side of the range from High Falls Creek belong to the Lake Harris schists of McKay's report, and from High Falls Creek to the gorge of Hidden Falls Creek; and it is only for a short distance that the serpentine runs along the outside edge of the bush.

Wherever, from faults or other causes, the Maitai rocks along the eastern side of the unaltered rocks make junction with the underlying metamorphic rocks, serpentines are absent. The character of the serpentines along the eastern belt is very similar to that along the westward, only the serpentines as well as the felsitic rocks are highly charged with sulphides, copper-pyrites being not uncommon in them.

It is this eastern line of serpentine, where it extends into the Greenstone Valley, that was examined by Mr. Cox (Geol. Rep. 1878–79, p. 53). Mr. Cox states that veins and bands of black serpentine occur in the Te Anau series, as developed in the Greenstone Valley, and I take this as confirmatory of the foregoing views.

Conclusion.

From what has been stated, it will be seen that there is a difference of opinion as to the mode in which the materials forming the western belt of olivine and serpentine rocks made their appearance. Park speaks of them as "eruptive rocks," and Professor Ulrich describes them as intrusive, while Mr. Cox favours the supposition that in their origin they were contemporaneous with the deposits of the formations with which they are found associated. I speak without hesitation on this point, because it is not in this part of New Zealand alone that the evidence of the interstratification of the magnesian rocks with the Te Anau series, and the relation of the massive developments of such rocks occurring at the base of the Maitai series, and interposed between it and the upper beds of the Te Anau series, may be studied.

The evidence in connection with a much more massive development of olivine and serpentine rocks in the Dun Mountain Range, Nelson, is apparently perfectly conclusive, and has been very clearly stated by Mr. McKay, who made a special survey of the district in 1878. (Geol. Rep. 1878–79, p. 111.) He says, "I shall not attempt to decide this question whether these rocks are mainly intruded or only the metamorphosed (altered) materials of an igneous outburst, contemporaneous in part with the lower rocks of the Maitai formation, and wholly subsequent to the deposition of the underlying breccias, slates, and sandstones of the Pelorus Valley. The interlamination of a portion of the higher part of this series (breccias) with the lower beds of the Maitai formation, and the production of conglomerate breccias between that formation and the serpentine belt, certainly indicates a sinking land-surface while yet the agencies employed in the production of the rocks of the mineral belt were active. In saying this much I commit myself to the theory that the mass of the rocks forming the mineral belt have been spread over a land-surface or shallow sea-bottom much in the same fashion as volcanic products may be so distributed in the present day. Nevertheless, I do not wish to be understood as contending that no intrusive rocks are to be found within the limits of the mineral belt; yet I venture to affirm that these will be found to be confined to the mineral belt itself, or the underlying formation, as, at the present time, I am not aware of the existence in this part of the district of a single dyke in any part of the area covered by the overlying Maitai formation. The further proof that the rocks of the Dun Mountain mineral belt do not form 'an immense dyke of intrusive rocks' are that, throughout the greater part of its extent, in a north-east and south-west direction, it passes under the same bed of the overlying series (the Maitai limestone), and that, on the north-west side of the syncline formed by the Maitai formation, immediately the Maitai limestone is reached or passed (for sometimes, as already shown, an interstratification takes place), we have a repetition of the rocks of the mineral belt of which the serpentine of Wakapuaka may be considered an example, but of which the rocks of Brook Street Valley and the Wairoa Gorge offer the greatest proofs."

Similar evidence may be collected in the southern locality which I have been revising, and the fact that the serpentines terminate abruptly on the east side of the belt, as though appearing along a line of fault, and that the schists abut with discordance against the serpentine, to my mind only proves the unconformable relation of the serpentines to the underlying and much older schistose rocks.

WAIPARA.

This district of North Canterbury has been rendered classical ground for the New Zealand geologist since 1861, when the late Mr. T. Cockburn Hood discovered bones of fossil reptiles which were described for him by Professor Owen. Since that date many geological examinations and extensive collections have been made, and, although there has been left no reasonable ground to doubt the stratigraphical identity of the reptilian beds at Waipara with those at the Amuri Bluff, the fact that none of the characteristic Secondary fossils had actually been found at Waipara left a certain degree of doubt on the subject in the minds of some critics.

The saurian collections were large and unique, but these were not considered as conclusively proving the Secondary age of the strata, especially as the bulk of the fossil Mollusca from the same beds seem rather to indicate a Tertiary age for the deposits. A fragment of a Belemnite and species of Aporrhais and Trigonia, which occur also at Amuri Bluff, seemed to be the only direct proofs of the Cretaceous age of the Bobbie's Creek beds, apart from the Saurian remains themselves. The other forms of Mollusca collected, though many were common to the Secondary beds at Amuri Bluff, had a Tertiary facies, and not a few of the genera are supposed to be confined to the Tertiary period.

Successive failures to prove the age of the beds by the fossils were disappointing, and led to attempts to correlate the beds with their supposed equivalents by means of stratigraphy, and the sequence of the prominent lithological characters of the various divisions of the strata constituting the Waipara formation. Over wide areas a correspondence of the sequence in regular and in varying order was traced, and at very many places in both Islands those beds proving richly fossiliferous were largely collected from. But the palæontological evidence over the whole of southern Canterbury and Otago, and on the west coast of the South Island, was apparently wholly in favour of the Tertiary age of the beds; while in the north-east, or Marlborough district, of the South Island, and along the east coast of the North Island, between Cape Palliser and Cape Kidnappers, and from Poverty Bay to East Cape, the evidences obtained from beds stratigraphically and lithologically the same demonstrated their Cretaceous age.

The progress of the survey rendered it necessary in 1877 to reconstruct the scheme of classification previously in use, and in this the term "Cretaceo-tertiary," which had then been in abeyance and disused for some years, was revived; and under the comprehensive term were included all the strata from the coal-beds of the east and west coasts of the South Island, and the west coast and northern parts of the North Island, to (and including) the marly clay beds that overlie the Weka Pass calcareous greensands.

The Waipara and Amuri series were at this time considered distinct from the Cretaceo-tertiary series, and were grouped as of older date, under the term "Lower Greensand formation;" but, while it has been contended, and even generally admitted, that there may be a certain amount of unconformity separating this horizon from the lower beds of the Cretaceo-tertiary series, the further work of the survey tended to show that the Lower Greensand formation was almost universally followed conformably by the Cretaceo-tertiary series, and that, too, in a manner which but little supported the idea of any unconformity separating the lower beds and higher beds of the two formations.

The Black Grit at Amuri Bluff was made the lowest bed of the Cretaceo-tertiary series, because it was considered that the Amuri series underlying this yielded conclusive proof of the Lower Cretaceous age of the beds. So also of the beds covering a large area between Kaikoura Peninsula and Cape Campbell, and along the east coast of the North Island. But there has always been a difficulty in determining, when examining localities distant from Amuri Bluff, what shall and what shall not be referred to the Amuri series; and at Motunau and Weka Pass, at the Waipara, in the Malvern Hills, and in the Trelissick Basin, the lower beds of the sequence, though still denominated Waipara beds, cannot with good reason be separated from the overlying Cretaceo-tertiary age, being developed at or near the base of the sequence, with no marine beds underlying.

It is necessary to say that the classification of 1877 was not in accordance with the views entertained by Professor Hutton, who objected to the use of the collective term Cretaceo-tertiary, and contends that there is a distinct unconformity existing between the Weka Pass calcareous greensand and the Amuri limestone and all beds that may chance to overlie it elsewhere, excepting a yellow sandstone in the vicinity of Flaxbourne and some beds following the Amuri limestone at Green Hills, near Kaikoura.

This unconformity, it is contended, is both stratigraphical and palæontological; but, in my opinion, this view has never been established with sufficient clearness to counterbalance the weight of evidence afforded by the general structural geology of all districts to the effect that the Grey Marls, which are probably of Lower Eocene age, do really close the series, and indicate a tranquil deep-water deposit preceding the volcanic outbursts of the Middle Eocene, or Hutchinson's Quarry beds, which form the base of the Oamaru (not the Ototara) group.

The coal-beds at the base of the sequence at Motunau, Waipara, and the Trelissick Basin have but a local development of breccias between them and the old rocks, while in the Malvern Hills the marine Amuri series is either absent or is represented by beds higher than the coal at those places.

From the fossil shell-beds over the coal at the places mentioned collections have been made containing characteristic Mollusca of the Amuri series, as developed at the Amuri Bluff; and at Amuri Bluff the supposed characteristic shells of Waipara and the Malvern Hills have been found not in beds overlying the Black Grit, but in the lower marine beds of the Amuri series.

At Amuri Bluff the Black Grit has been correlated as occupying nearly the same horizon as do the coal-beds further south along the east coast of the island; but it must be noted that traces of coal are not wanting at the base of the Amuri series, and it may be reasonably asked if the Amuri series is more than a local expansion of the black oyster-bed and other fossiliferous strata that intervene between the coal and the saurian boulder-beds at Motunau, Waipara, Malvern Hills, and elsewhere along the east coast of the South Island, and this apart from any evidences of unconformity that may have been noted between the Amuri series and the greensands and calcareous beds of the higher part of the sequence. There is indeed evidence in favour of the supposition that the Amuri series has representative beds in the localities above indicated; at all events, not a few fossil forms are common to the Amuri series and the lower beds of the Cretaceo-tertiary series; but also in the Waipara, at the Malvern Hills, and in the Trelissick Basin, there are many species common to the fossiliferous beds over the coal in South Canterbury and North-eastern Otago; and it was mainly for the purpose of making a collection in proof of the relationship subsisting between the Waipara beds and the coal-bearing series in South Canterbury and North-east Otago that this latest examination of the Waipara beds was undertaken.

The results obtained are very satisfactory and of an important character, and prove not only the close palæontological relationship of the Waipara beds with the coal-beds in the South, but also a very close relationship with the Amuri series in the North; and the palæontological evidence is now in accordance with the geographical distribution, stratigraphical sequence, and lithological characteristics of the beds throughout the region of the east coast of the South Island.

MOUNT ROYAL IRONSTONE.

On the 9th November I visited Palmerston South for the purpose of examining the deposits of iron-ore at the western base of Mount Royal. The existence of this deposit had been discovered during a previous survey of the district, and samples brought to Wellington yielded, on analysis at the Colonial Laboratory, 38 per cent. of iron, mostly carbonate of iron or spathic ore. Subsequently some doubts arose as to the occurrence of such an ore in bulk in the locality indicated, and to set this matter at rest was the main object of my visit.

The examination made clearly proves the existence of a very large body of iron-ore exposed along the lower slopes of Mount Royal, and also in the low grounds of Pleasant Valley, and on the opposite hill-slopes; and a large bulk-sample was obtained for display in the Mineral Court of the Dunedin Exhibition. The ore occurs in large concretionary masses in the greensand overlying the coal-seams. These masses acquire a rusty surface on exposure to the air. Ore taken from the centre of the concretion is of a green colour, subcrystalline, and contains 66 per cent. of spathic ore (carbonate of iron), mixed with 19 per cent. of glauconite (silicate of the protoxide of iron), the remainder being carbonate of lime and other bases. This green variety of spathic ore is somewhat rare.

COAL-PROSPECTING AT OTAKAIA.

During the month of December Mr. McKay examined the coal-prospecting work at Mr. Blair's farm, near Otakaia. On this property three prospecting shafts have been sunk, the deepest being 60ft. from the surface, but without finding evidence of the presence of workable coal-seams. The coal-measures in this neighbourhood consist mainly of fine-ground sandstone of a light colour, associated with beds of quartz-grit and beds of slaty breccia derived from mica-schist. The prospecting works on Mr. Blair's property have also shown the presence of one or two bands of calcareous cement stone.

There is little doubt that the beds prospected belong to the coal-bearing series of Green Island and the east coast of Otago further south, but nowhere in the near vicinity of the prospecting works lately carried on have any outcrops of anything at all approaching a workable coal-seam been observed.

On Mr. Blair's property the coal-measures form a syncline, the lower beds of which, on the south-east side, rest on Palæozoic rocks, exposed on both sides of the Lower Gorge of the Taieri River, and stretch as a ridge of hills along the coast-line to New Brighton. Coal, it has been stated, is found as rolled boulders in some of the small streams towards the outcrop of the lower beds in this direction, but no steps have been as yet taken to verify or disprove the report. It is in this direction that a workable seam appearing at the outcrop should be looked for, and the report, resting on the authority of Mr. McCabe, of Henley, is in all probability correct. The underlying slate-formation appears in the deep gully less than a mile to the east of Mr. Blair's farm, and the sides of this ravine can without much difficulty be prospected so as to prove whether or not any seams of workable thickness are present. This, it may be suggested, would be a readier method of proving the ground than by the continuance of the prospecting shafts, or by boring to greater depths than yet reached within the boundaries of Mr. Blair's farm.

North of Mr. Blair's property, and nearer the south-east slope of Allan's Range, prospecting for coal was some time since carried on on Mr. Palmer's land, and it is said that a thin seam about 1ft. thick was passed through; but, as it is some time since these works were discontinued, the locality was not visited, and nothing further respecting the existence of coal in that neighbourhood has been ascertained.

While coal-prospecting has thus not been attended with that success which could be wished, the examination of the district shows clearly that an area of coal-measures about three miles in width lies to the east of the main road between Greytown and the bridge over the Taieri River at the upper end of the lower gorge.

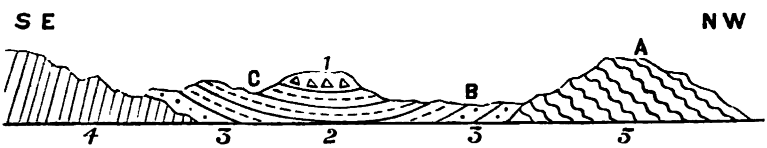
Striking the same direction, the coal-rocks on the south-east side of the syncline, already mentioned, cross the Taieri River, and are continued in a south-west direction some distance—how far has not been exactly determined. In the section from Waihola Township along the road east to the coast-line coarse gravels rest on the old rocks to the east, and these cannot with certainty be referred to the lower coal-bearing part of the formation, if, indeed, they are referable to the Cretaceo-tertiary formation at all.

HENLEY BRECCIAS.

Extending along the north-western side of the belt of country described as coal-bearing is a remarkable deposit consisting of huge angular blocks of schistose material, intermixed with finer material of the same character, often also mixed with red clay, which I took a recent opportunity of examining.

This deposit shows in the lower hill-slopes before reaching Otakaia from Greytown, but near the schoolhouse at Otakaia the soft sandstones underlying for a short distance along the road make their appearance.

Further along the road towards Henley the breccias appear as a massive development, and form all the outer hills bordering the Taieri Plain as far as the Taieri River. Palæozoic slates appear near the Taieri Bridge on both sides of the river, and on these the breccias are seen resting without the intervention of the lower beds of the coal-bearing series; and on the lower north-west slopes of the hills east of the railway-line the slate rocks appear as far as the first station beyond the Taieri Bridge. Beyond this, grits and conglomerates continue to Waihola Township. From Otakaia Township these breccias reach south-east to the nearest boundary of Mr. Blair's farm, but are in this line of section not composed of such massive material as is seen in the nearly-parallel section from Henley south to the Taieri River.

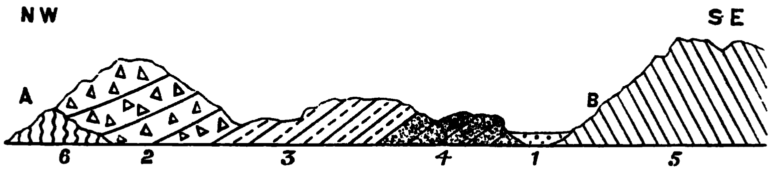


Section from Allan's Range, Greytown, S.E. to Coast Range. 1. Coarse breccia. 2. Soft sandstone. 3. Grits and fireclays. 4. Slate rock of Coast Range. 5. Sub-metamorphic schists.

Along the north-east bank of the Taieri River these rocks are well seen in section between the bridge on the main road to

Waihola and the entrance to the higher and more confined part of the gorge, two miles below the bridge. The dip of all the younger rocks in this section is constantly to N.W., and thus the section to the south-east shows coal-grits, &c., resting on the old rocks just within the Taieri Gorge, which, up the river, are followed conformably by the Henley breccias. At Henley the beds dip slightly to S.E., and on the hill-tops immediately to the south are nearly horizontal. On the south-west side of the Taieri River the dip is N.W. at high angles almost to the junction of the breccias with the old rocks.

The following section illustrates the disposition of these breccias and the underlying coal-rocks along the left bank of the Taieri below the bridge:—

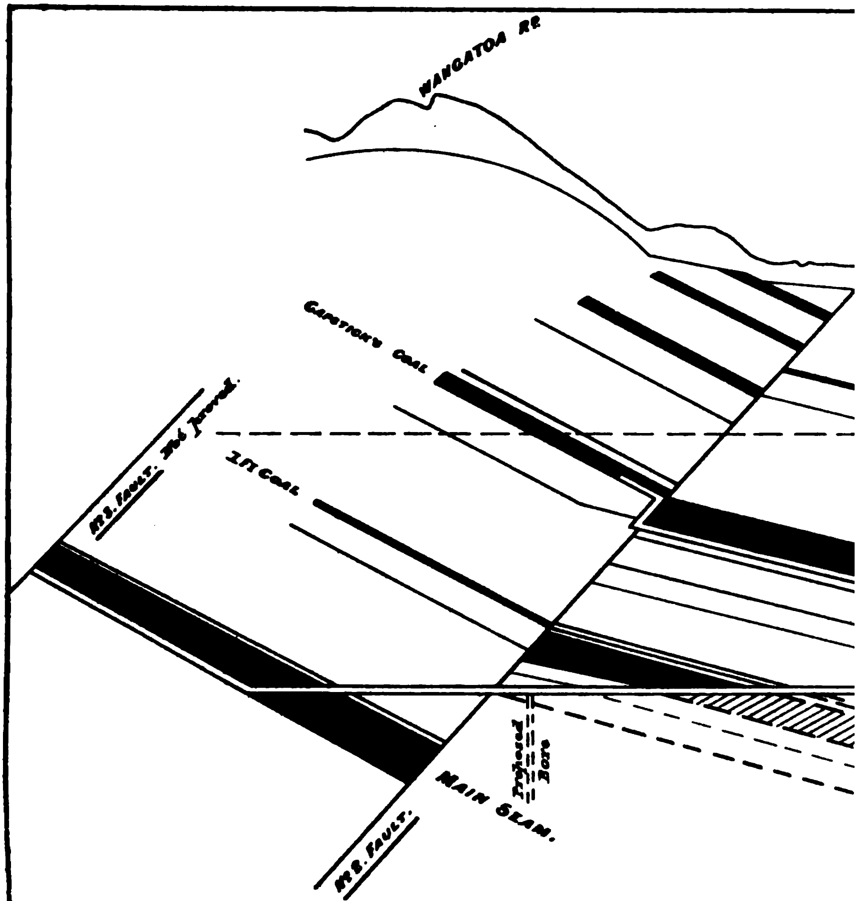


Section along left bank of Taieri River. 1. Alluvial. 2. Breccias. 3. Sandstones and grit. 4. Lower beds of coal sequence. 5. Old rocks of the lower part of the Taieri Gorge. 6. Subschistose rocks near Taieri Bridge. A. Taieri Bridge. B. Entrance to the lower gorge.

The evidence obtained near Otakaia, at Henley, and along both banks of the Taieri River, in each case points distinctly to a condition of conformity, apparent or real, between these breccias and the underlying beds of the coal-bearing series.

Within the Township of Waihola sands and sandy clays, invaded by volcanic rocks as old necks or intrusive dykes, are exposed at the base of and underlying the breccias. These sands, &c., have yielded to Mr. McKay a few fossils and fish-teeth, &c., which seem to point to the Miocene age of the fossiliferous beds.

East and south-east of Waihola the breccias form hills reaching 600ft. to 800ft. above the sea, and are exceedingly coarse in character, numberless blocks of schist 10ft. to 12ft. or more in diameter appearing on the hill-slopes of the front range of hills. In the section along the road from Waihola to the coast and Township of Hull, at the mouth of the Taieri, the breccias have a great development. They are arranged as a syncline, the eastern side of which rests on the slates and sandstones forming the sides of the deep gorge by which the road from Waihola reaches the coast-line. On this side of the



Geological S

SIR JAMES

SECTION

KAITANG

From Section furnished by Mr W. M. Shor

syncline coarse well-rounded gravels make contact with the old rock, and the lower fossiliferous beds of Waihola are absent.

Beyond Waihola the breccias continue in a south-west direction to a point east or south of Waihola Gorge, where they form the higher part of the range ending in Trig. Hill 1,200ft. above the sea, and overlooking Tokomairiro Plain.

There is no apparent connection between these rocks and the calcareous rocks and underlying greensands of the Waihola Gorge, which in the general sequence are placed so as to overlie the rocks of the coal-bearing series. It is, however, significant that the roof and cover of the coal at Kaitangata is composed of a coarse conglomerate resembling these breccia-beds.

The fossils found in the beds at Waihola Township do not form a collection of sufficient bulk or importance to definitely settle the age of the beds in which they occur, and, except the teeth and other fish-remains, they have not yet been examined by any authority of repute. The fish-remains represent the genera Trigon, Lamna, and Notodanus, but do not appear to have been sufficient for the determination of the species to which the remains, teeth and spines, should be referred.

Among the Mollusca present, Marginella, Pleurotoma, and Conus, apparently of the same species as are found in the Miocene Awamoa or Pareora beds, are the most prominent, and, so far as the evidence goes, the beds should thus be referred not to the Cretaceo-tertiary, but to the Miocene period.

So far, therefore, this evidence compels the assumption that, in spite of apparent conformity of the coarse gravels and breccia-beds at Otakaia, Henley, and Kaitangata, they must be assumed to be unconformable to the coal-bearing series—otherwise, to be of Tertiary age. The breccias above described were noted and mapped during the geological survey of Otago prior to 1864, and are shown on the large-scale manuscript map bearing that date as an outlier of the alluvial deposits of the interior basins or plains of Otago. Professor Hutton describes it as an "immense accumulation of clay and angular blocks of schist of all sizes that is found on the eastern side of the Taieri Plain, extending from the Taieri River nearly to Otakaia, a distance of about three miles" (Geol. of Otago, p. 62).

The determination of the true relation of these beds to those of the coal-bearing series is a matter not of interest merely, but of considerable practical importance; but it seems necessary that a further and complete survey of the whole of the coast district between Green Island and the mouth of the Molyneux must be undertaken before the age and true position of these beds can be with certainty determined.

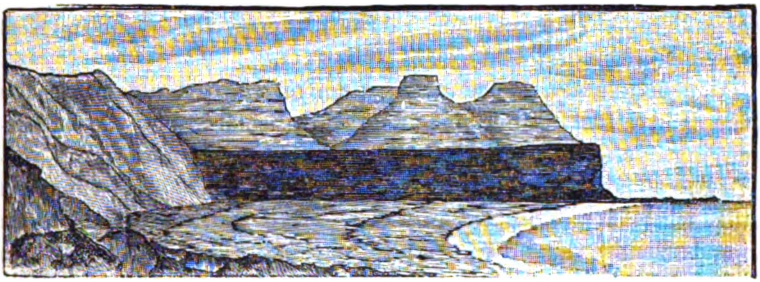
The only other fossiliferous beds hitherto known are on the sea-coast at Measly Beach, north of Coal Point, but their stratigraphical relations have never been made out. Within the last few months, however, in a shaft on the Castle Hill coal leasehold, in the Township of Kaitangata, a fossiliferous greensand has been passed through which is evidently of the same age. From the collections made for comparison thirty species of marine shells have been obtained from the Measly Beach beds, and forty species from the Castle Hill shaft.

At first sight, in the case of both collections, the rough blocks collected in the field seemed to indicate a Miocene or Pareora age for the beds from whence they came; but, on the collections being worked out, a considerable number of species were found that indicate a horizon inferior to the Ototara stone (VI.*b*) and the calcareous sandstone occupying the same position in South Canterbury.

The material from the Castle Hill shaft also proves to be identical with the black limestone of Tokomairiro (No. 41 of the Index to Fossil Localities), the age of which is given as VI.*e*, and which certainly underlies the Waihola limestone, the nearest calcareous representative of the Ototara stone. Hence, stratigraphically, the beds cannot be the equivalents of the Awamoa beds near Oamaru, or of the Pareora beds in southern Canterbury.

On working out the collection from the Castle Hill shaft a number of fossils common in the first fossiliferous horizon over the coal at Black Point, Waitaki Valley, and at the Kakahu, South Canterbury, were found. These include Volutilithes, which is totally absent from the Miocene beds of New Zealand. Pleurotoma and Natica are present, but the species are the same as found in the Onekakara beds at Hampden, Moeraki, and at the Waihao in South Canterbury. The Crassatella common in the greensands of the Waihao occur in the Castle Hill beds; and altogether, while there are no distinctively Cretaceous forms in either of the collections, it is only a form of Turritella allied to *T. vittata* (Hutton), a variety of *Crassatella traïlli* (Hutton), and a small Cardium resembling *C. striatulum*, that might lead to the belief that the beds are the equivalents of the Miocene Tertiary beds of north-east Otago and southern Canterbury.

The evidence that will be afforded by the Castle Hill shaft when completed to cut the coal will be most valuable. The great importance of the Kaitangata coal-measures, and their total difference in character from the lignite-bearing strata that occur in our Tertiary system, can be appreciated at a glance by reference to the section, drawn on the natural scale from actual measurement, which has been kindly furnished to me by the manager, Mr. W. M. Shore. The remarkable appearance of the great coal-seam that forms Coal Point is shown in the following sketch.



MANGANESE.

An interesting development of manganese lodes on the south of the Taieri Mouth, in Otago, was examined and reported on last year, the first discovery of the deposit having been made by myself in 1862.

The coast-range which, from a little south-west of Brighton, is continued to beyond the Tokomairiro River, consists of slates and sandstones, always much indurated, and sometimes, as in the lower part of the Taieri Gorge, so altered as to present the structure and appearance of a subschistose rock. At other places the rocks of what appears to be the same formation are less altered, and in appearance correspond to the ordinary and normal condition of the Te Anau and Maitai series. At the present time I am inclined to refer the whole to the Kakanui series. Mr. McKay, however, thinks that an unconformity may be traced and a distinction made between the rocks of the lower part of the Taieri Gorge and those forming the eastern half of Taieri Island and the mainland to the south to and beyond the manganese mines. The junction referred to is well seen at the south-west end of the sandy beach on the mainland opposite and south-west of Taieri Island. Here the grey glimmering subschistose rock of the Taieri Gorge ceases, and nearly vertical strata of dark mudstones, with masses of included quartz, form the lower beds of the succeeding series. These dip to S.E., and are succeeded by red and green jasperoid rocks, solid or brecciated, followed in turn by fine breccias and coarse sandstones that continue along the coast to the neighbourhood of the manganese outcrops.

The rock-formation in which the ore occurs is along the junction of the Maitai (Lower Carboniferous) and Te Anau (Upper Devonian) formations, which corresponds with the horizon of the best-marked mineral developments in New Zealand—such, for instance, as the chrome and copper lodes of the Nelson mineral belts.

Unfortunately, I had not a plan of the ground which has been leased for mining purposes at this place, but the accompanying eye-sketch will serve to illustrate my remarks.

The locality is the northern extremity of a coast-range of hills, where it terminates in a flat-topped spur, bounded on the inland side by the brown-coal formation. The spur is about a quarter of a mile wide, and slopes gently to the sea. The main road follows the crest of the ridge.

The strike of the rock is N.–S., and oblique to the direction of the ridge, so that the strata show in succession on the sea-beach.

Five outcrops of ore have been opened out, the exact spots having been chosen because of surface indication where the lodes have been intersected by gullies, as shown on the plan.

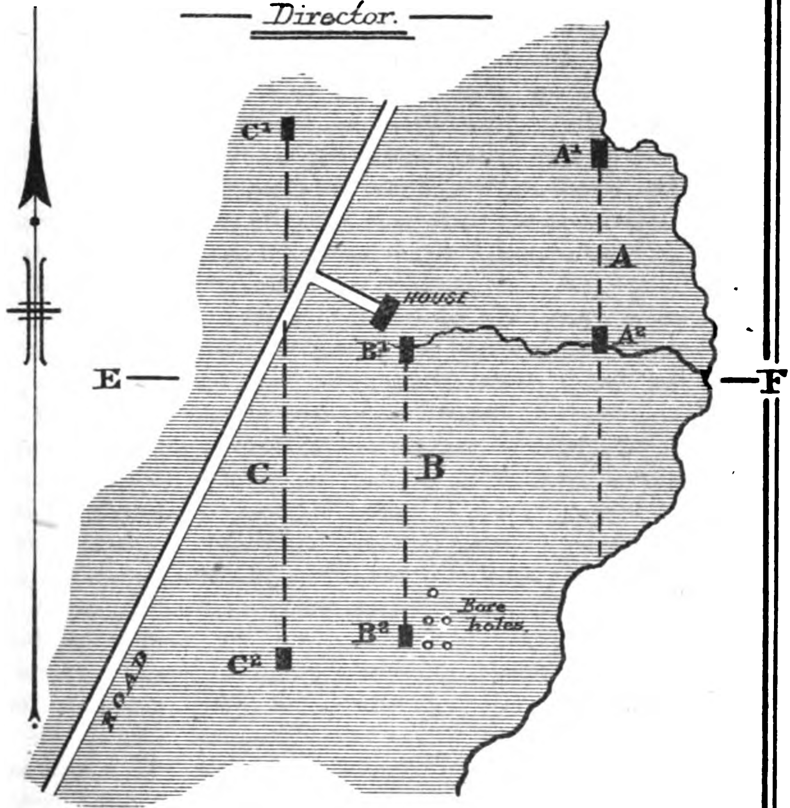
No attempt has yet been made to trace the lodes in the solid parts of the hill between the outcrops; but, as the ore occurs distinctly imbedded in the slaty rock, there is no reason to doubt that it will be continuous, although varying, perhaps, considerably in purity and thickness.

The best exposure of ore, although not of the best quality, is that which was first opened up at the point marked C^1 on the west side of the main road. At this place a large quarry has been opened, or, rather, benched out, in the hillside. The strata exposed dip at 37° to E., the section being as follows:

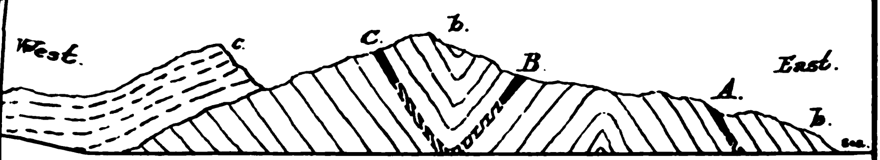
(*a*.) Cover of red- and purple-coloured slate, imperfectly cleaved.

(*b*.) Band 12ft. in thickness of rock impregnated with manganese-oxides. This ore-band is very much decomposed, and is traversed by quartz veins from ⅛in. to 1in. wide, and also veins of soft yellow and white pipeclay. About 50 per cent. of this band

SKETCH PLAN & SECTION
showing
Probable distribution of the
MANGANESE LODES.
SOUTH TAIERI DISTRICT.
To illustrate Report by Sir James Hector. F.R.S.
Director.



a. Te Anau Formation. b. Maitai Formation. c. Brown Coal Formation.
A. B. C. Manganese Ore Outcrops.



SECTION ON LINE E.F.

is good solid ore, and of this about 100 tons has been excavated. A sample of this ore in its purest and most compact form proved on analysis to contain 79·16 per cent. of oxide of manganese, and $\frac{1}{8}$ per cent. of oxide of cobalt; but the excavation has not yet been extended to a sufficient degree to enable the nature of the solid ore to be ascertained, as all that shows is more or less decomposed, and altered into inferior ores. (*c.*) The ore-band rests on purple and grey mottled slate, having a soft, flaky structure, very probably an ancient ash-bed, associated with diorite porphyry. Crossing the hill on the line of strike for a distance of about 400 yards, what I take to be the same structure is met with in a deep gully at C^2. The excavation made at this point has slipped, so that the section is not very clearly seen, but the dip appears to be also to the east, as in the case of C^1.

The ore-band-containing rocks are very much decomposed, and stained with delicate shades of green, suggesting the presence of nickel-salts. Samples taken have been tested, and gave no trace of nickel, but very good indications of cobalt.

Further down the same gully, at B^2, the ore was again found, and large excavations made. Some of the best ore which has been shipped was obtained here. The sample which I took for analysis seems to have been unfortunately selected, as it contains a high percentage of iron and siliceous matter; but the manganese-oxide present, equal to 29 per cent., is in the form of the more valuable peroxide.

The band of ore at this place now dips to W., as is clearly proved by the ore obtained by a series of bore-holes which have been put down. I have therefore marked it as a different line of ore-band on the plan.

The ore-band seems to be very strongly developed at this place; and on following the line northwards to the next gully, close to Mr. Huon's farmhouse, the ore is again met with, also mixed with a large percentage of iron; but here the manganese, judging from the samples I took, is in the form of a less valuable sesquioxide.

Following down the Farmhouse Gully a fifth outcrop has been opened up in a mass of very compact black ore, which is a massive form of manganite, containing samples giving 87 per cent. of sesquioxide of manganese and 10 per cent. of water.

As the rocks with ore-band at this point again dip to the eastward, this must be again a distinct or third line of ore, and the northern extension of this same line is probably to be found at the rocky point on the coast at A^1, where very fine specimens of manganite have been obtained.

I believe this is also the spot where I found the first specimen of the ore in 1862. Along the coast the section is not very clear, but changes in the dip corresponding with the foregoing can be fairly well made out. No outcrops of the manganese are exposed in the rocks on the beach, but such are hardly to be expected, as the ore would be decomposed; but in the proper strata from line C the rocks are stained with manganese and iron, and contain quartz veins which yield distinct traces of gold on analysis.

From the foregoing I infer that there is only one layer of rock which carries the manganese-ore, but that this layer is three times brought to the surface by rolls in the strata, as shown in the section on the plan. This, at least, is the theory upon which I should recommend further mining works to be extended.

In most other localities manganese-ore is found to vary greatly both in its thickness and purity; and the great range in the composition of the samples, which I selected at random, proves that the same uncertainty will prevail here also. It therefore hardly matters where the mining is commenced, except that on the whole the ore is more massive and of better quality on the A line, next the coast.

I attach a schedule of the analyses of the samples I collected, with reference to the localities on the plan, and also give the results of the analyses performed some years ago for Mr. Josephs, but from which of the outcrops the samples were taken is not known :—

RESULTS OF THE ANALYSES OF FOUR SELECTED SAMPLES. (Lab. No. 5,540.)

Marks on Sample.	Manganese Peroxide.	Manganese Sesquioxide.	Ferric Oxide.	Cobalt Oxide.	Siliceous Matter.	Water.	Manganese Metal.
Outcrop A[1]	..	87·01	0·10	0·26	0·63	10·34	58·1
Outcrop C[1]	..	79·16	5·22	0·23	1·63	10·08	55·4
Outcrop B[1]*	..	44·19	37·42	Trace	5·62	8·66	30·8
Outcrop B[2]	29·01	..	40·26	Trace	18·14	4·19	17·0
ANALYSES QUOTED FROM LONDON REPORT. (Lab. No. 4,455.)							
..	..	90·13	0·49	..	0·32	9·11	..
..	..	88·43	0·87	..	1·21	9·49	..
..	..	69·36	3·60	..	7·23	19·81	..

* Solid ore, Huon's house.

ANALYSES PERFORMED IN LONDON ON SAMPLES OF VARIOUS SHIPMENTS.

No.	Manganese.	Peroxide of Manganese.	Protoxide of Manganese.	Magnesia.	Sesquioxide of Iron.	Peroxide of Iron.	Oxide of Iron.	Oxygen.	Alumina.	Oxide of Copper.	Oxide of Cobalt.	Lime.	Phosphoric Acid.	Silica.	Carbonic Acid.	Combined Water.	Moisture.	Baryta.	Oxide of Zinc.	Sulphuric Acid.	Sulphur.	Sulphate of Baryta.
1	57·40	..	..	..	1·40	..	..	30·05	3·05	0·08	0·15	0·30	0·55	2·00	None	2·02	2·00	..	..	..	..	..
2	55·10	..	..	0·20	1·50	..	..	30·80	2·10	0·07	0·20	2·05	0·97	2·95	..	3·51	2·00	..	..	..	..	0·50
3	52·45	75·82	5·48	..	..	..	3·30	..	0·82	None	..	0·92	0·41	8·42	..	2·40	52·45	0·32	0·35	Trace	..	..
4	..	..	31·62	1·76	..	Traces	5·36	..	7·69	..	..	6·62	0·25	23·97	20·95	..	1·42	..	..	..	0·17	..

It appears from advice received that the value of manganese-ore is 1s. 7d. to 1s. 8d. per unit of metal in the ore.

NENTHORN REEFS.

About the middle of December Mr. McKay visited Nenthorn district, which during the past eighteen months has come into prominence on account of the discovery of auriferous reefs there. The existence of auriferous-quartz reefs in the district east of Strath-Taieri has been known since 1864; and the Duke of Edinburgh Reef, at the upper end of Macrae's Flat, and the Highlay Hill Reef were prospected and partly worked many years since; but the yield in neither case seems to have been quite satisfactory, since for several years, up till the Nenthorn discovery, all work on these claims has been discontinued.

The Highlay Hill Reef forms a large body of stone, and on this account a low percentage of gold may be made to pay. Within the Duke of Edinbugh Claim the reef is seldom more than 2ft. in width, and in its eastern extension seems to die out, or exist only as a mullock-band. Samples obtained and tested in the Colonial Laboratory returned as much as 2oz. of gold to the ton of stone. The reef has been worked along the outcrop for a distance of five or six chains to a depth of fully 20ft. in places; but no regular underground mining appears to have been done. Professor Ulrich reported on these mines in 1875. (Geol. of Otago, Hutton and Ulrich, Dunedin, 1875.)

The centre of the Nenthorn reefing district lies about from seven to nine miles south of Macrae's Flat, and there within the past two years the nucleus of a township has sprung up. Reefs are numerous, and for the most part are found to be gold-bearing.

The area in the vicinity of Nenthorn over which reefs have been found and partly worked seems to form part of an extensive region where auriferous lodes are likely to be found, and which may be described as extending from the southern border of the Maniototo Plain through Highlay Hill to Tuapeka, with a breadth on each side of the median line through Nenthorn of four to five miles.

Within this belt of country there are numerous reefs, which, with few exceptions, trend nearly E.–W. across the belt, and dip at considerable or high angles to N. For the most part the reefs do not exceed 2ft. or 2ft. 6in. in thickness; there are one or two massive lodes of greater thickness, but the general average will be found to be somewhat less than 2ft. Many lodes are being prospected that have a thickness that does not average more than 12in. This thinness of the reefs is to some extent balanced by the comparative richness of the stone, as evidenced by prospects panned out of samples crushed in the mortar at the mine or obtained by analysis elsewhere. These evidences of the richness of a mine are not, however, always to be relied on, and bulk samples must be treated before the average yield of particular reefs and of the whole field can be determined. So far, crushings have not yielded much more than paying results.

Ordinarily speaking, water is not abundant, and steam will have to be substituted as a crushing-power; and the cost of cartage of coal from Palmerston or Shag Point Mine must, until better roads are made, be very considerable. Coal is known to occur as workable seams on Hummockside, on the west side of Stoneburn, at a distance of about ten miles from the centre of the reefing district, and if a supply of coal fit for the purpose can be obtained from that locality the cost of milling may thus be rendered considerably less. Coal-measures, or, rather, deposits of quartz-gravel underlying the horizon of the coal, occur about five miles to the south of Nenthorn Township. Mr. McKay made examinations in this direction in the hope of finding coal at a yet more convenient distance than that on the Stoneburn. It, however, turned out that in this direction the lower quartz drifts are immediately overlain by sheets of basalt, and, while the cements and quartz-gravels thus protected may prove auriferous, there is little chance of coal being found under the capping of volcanic rock.

The fundamental rocks of the Nenthorn district must be included within what are denominated foliated schists, which as a formation or series occupies the greater area of the Otago goldfields. Quartz foliæ are perhaps not so abundant as in the lower contorted and calcareous schists of the axis of the great anticline running south-east through the gold-bearing region; but the Nenthorn rocks are more allied to these than to the arenaceous schists and phyllites that upwards gradually lose their schistose character, and pass into the semi-metamorphic rocks of the Walter and Cecil Peak series, and the unaltered rocks that form the Kakanui series.

The Nenthorn rocks are intersected at frequent intervals by a system of joints running north-and-south, and by another system running at right angles to these, or nearly so; and these facilitate greatly the production by atmospheric denudation of the numberless castellated projections that stud the surface of this and the neighbouring districts of central Otago, and also the formation of the deep ravines lying below the general level of the country.

The north-and-south joints do not appear to be more than planes of jointage, as they have never opened mineral infiltrations, or mullock-lodes resulting from friction, or the infilling of detritus from the surface. It is different with the east-and-west joints. These have been opened to form true fissures, and for the most part have been filled with quartz carrying gold, copper, antimony, and manganese, and usually an abundance of iron-pyrites. One or two of the reefs being worked trend east-south-east, and may belong to a third system of joints; but the far greater number of reefs conform to the direction of the system of joints running east-and-west.

The reefs are traceable for long distances at the surface, and under favourable circumstances for examination are seen to be as constant in the vertical direction. The conclusion from these facts, therefore, is that, provided the reefs are of sufficient bulk and richness to pay for working, there need be little apprehension as to their constancy in either direction.

There is one peculiar circumstance in connection with this field that is worthy of note—namely, the comparative absence of alluvial gold in the streams that drain that part of the district in which the reefs are most abundant and productive. This fact has not escaped the notice of the miners and prospectors who have arrived on the field since the discovery of the auriferous character of the reefs.

Gold, indeed, is not absent from the bed and alluvial banks of Nenthorn Creek and the other small streams draining south-west to the Taieri River; but the amount of alluvial gold obtained has not induced at any time the location of more than a few miners in the district, and it may be said that the different creeks have been prospected only to be abandoned as unproductive.

North-east and south-west of the township there are not less than a score of reefs directly crossing the watershed of the country, most of which have been proved to be auriferous; and yet, though the creeks have their present water-channels deep below the average level of the country, they are not gold-bearing even where rich lodes cross, and outcrop in, the bed of the stream. This is the more remarkable since free gold, and detrital quartz carrying gold, is abundantly liberated from the caps and outcropping parts of the reefs; but such auriferous gravel still lies on the hill-slopes and undulating table-lands, and has not found its way into the creek-bottoms. So far this might suffice for the absence of rich alluvia, but other considerations must convince any one that the country has undergone an amount of denudation to the extent of many hundreds, or even thousands, of feet of superimposed rock, which has been removed; and also that a considerable part of this denudation must have been effected under present surface conditions, and should have yielded to the creek-channels an amount of free gold much greater than actually seems to be present.

Yet the derived quartz and other auriferous material produced by this vast denudation is to a large extent still present in the district; for it cannot be doubted that the comparatively fragmentary patches of quartzose gravel which are found at frequent intervals on the coastward hills and thence extending inland to the flanks of the Rock and Pillar Range, and skirting and in part filling the Maniototo Basin, are only outlying fragments of an extensive and connected sheet. They are found on heights that overlook most of the country under consideration—Highlay Hill, for instance—and are present at short distances to the east and west and to the north and south of Nenthorn. It is a fair presumption that from these quartz-gravels has been derived much of the gold washed out of the creek-beds and alluvial flats of the country, and that, as these gravels once covered the Nenthorn area, the gold yielded from this source must have been supplemented by what was derived direct from the reefs since the removal of the protecting quartz-drifts. It is therefore remarkable that the creeks in the vicinity of the Nenthorn reefs should be so poor in alluvial gold, and a further study of the peculiarities of this region must be made before an explanation of the reason for this poverty can be arrived at.

ANTIMONY AT BAREWOOD.

More to the south-west, but within the boundaries of the belt of country already described, Mr. McKay examined some outcrops of antimony-ore on the Barewood Run. A fine sample of several bags of this ore was shown in the Mineral Court of the Dunedin and South Seas Exhibition, but in the lode the ore did not show to equal advantage, the better and more showy ore in the opening made having been worked out. No doubt, when further prospected other and equally good parts of the lode will be laid bare. More work is required to be done before an opinion can be ventured as to the value of this property.

UPPER POMAHAKA GOLD-DRIFTS.

During January of the present year Mr. McKay examined the auriferous drifts of the Waikaka at Switzers, and a portion of the New Zealand Agricultural Company's estate at Waimea in connection with the prospects of coal there.

Switzers.

The work at this place chiefly concerned the nature and disposition of the different drifts worked for gold. In approaching the mining centre and township of Waikaka from Riversdale, the road east of the Mataura River rises on to and crosses a broad terrace table-land between the Mataura River and the lower course of its tributary, the Waikaka. These terrace lands have been formed jointly by the two rivers, but mainly by the action of the Mataura. The gravels forming them are two or three hundred feet thick, and generally resemble, although more of schistose material, those of the Waimea Plain. Nowhere have gold-workings been opened in this terrace plain, and practically the materials composing it are non-auriferous.

Descending into the valley of the Waikaka, this is bounded at first by a range of hills, on the sides and slopes of which are gravels that are auriferous, and a mile nearer the township slate rocks appear in the low grounds, which are overlain by auriferous gravels as terrace deposits of the river at a former period. The present gravel-spits and beaches of the river near and above the township are known to be auriferous, and dredging operations are contemplated, which, it is anticipated, will yield highly satisfactory returns. Opposite and above the township, the low lands along the river-valley are bounded by a slaty subschistose rock, which should be referred to the Kakanui formation. These form the older rocks of the downs and cluster of low hills on both sides of the valley, on and over which have been and are worked the richest gold-deposits of the district. All the deposits on these are of greater age than those which have been mentioned as filling and fringing the valley-bottom and lower slopes on either side.

These high-level gravels are divisible, and form an upper auriferous drift, consisting of rubbly schistose material mixed with quartz more or less rounded, and a lower drift composed of well-washed and rounded quartz-sand and pebbly grit, in no way differing from the quartzose "made hills" of the old lake-basins of central Otago. At the base of these latter are clays associated with thick beds of lignite, which on the opposite side of the valley would appear to be overlain by marine beds, but whether these latter underlie or overlie the auriferous-quartz drift is uncertain. Mr. McKay was not aware at the time of his visit of the existence of these fossiliferous beds, or that a block of fossiliferous rock had been forwarded to the Dunedin and South Seas Exhibition, which, the sender states, was obtained 40ft. under the surface, from a claim on the west side of the valley opposite the township. This fossiliferous block was subsequently secured for the Colonial Museum, and on being broken up proved to contain a number of well-known shells that indicate a Miocene age for the beds from which it comes. There are also two or three species not known in the Miocene deposits of New Zealand, and among these a species of Arca and a very large form of Crypta that appear to be new.

Similar fossils with lignite-beds are found at many places along the east side of the Mataura valley, and in the Waipahi and Pomahaka watershed. The actual age of these beds cannot be said to be finally determined, as the evidence from the plant-beds of Landslip Hill is somewhat contradictory of their being of Pareora age. They have been set down as belonging to a brown-coal formation of Eocene or Cretaceo-tertiary age.

COAL, AND PROSPECTING FOR COAL, ON THE WAIMEA PLAINS.

The same beds with lignite that are found at Switzers occur on the west side of the Mataura, at Waimea, the Home Station of the New Zealand Agricultural Company; and there and at Mataura Falls they have been mined, or, rather, quarried, for many years past.

On Waimea Station, on the east side of Longridge Creek, four miles west of the Home Station, there is a small area of calcareous sandstone showing in the downs to the eastward of the stream mentioned. This calcareous rock is similar in appearance to and probably of the same age as the Forest Hill limestone on the opposite or west side of the Hokanui Hills, where, in the beds underneath the limestone, brown coal of excellent quality was discovered a few years ago. On the Waimea Estate it was anticipated that by boring through the limestone at Woolshed Creek a coal superior in quality to the lignite of the Home Station would be found, and boring operations were accordingly commenced at "The Wash," in the locality indicated.

After the surface alluvia and underlying calcareous rock had been passed through, at a depth of 190ft. from the surface a series of sandy and argillaceous beds were entered upon, which, as the grain and material corresponded well with the cover of the coal in other parts, seemed to give a hope of final success for the undertaking. At this stage of the proceedings, since the depth was considerable, the opinion of the department was sought as to the indications, and the propriety of proceeding further with the borehole. On the assumption that this must shortly reach the coal, or the bed-rock underlying, it was advised that the boring should be continued. This was done; but, failing to reach coal at a moderate depth below that reached, without further advice being asked, the boring was continued till a depth of 521ft. was reached; and throughout the whole of this depth no positive evidence of the existence of coal was obtained.

Work was a second time suspended, and subsequently Mr. McKay was sent to examine and determine what the evidences in favour of the existence of coal really were, and whether it was advisable to continue the prosecution of the works. After making an examination of the vicinity of the borehole, and such of the borings as were available, the nature of the lignite and associated strata near the Home Station was examined; and, further, it was deemed necessary to see such natural sections as are exposed along the banks of the Waimea River to its junction with the Mataura. This was done, and the railway cuttings for two or three miles in the direction of Gore were also examined.

These various examinations led Mr. McKay to the conclusion that the borehole for the lower 200ft. at least had pierced the Lower Permian, on which the Waimea calcareous sandstone and other superficial rocks rest. The evidence leading to this conclusion seems to be sufficient, and it can now only be regretted that these examinations were not made at an earlier date, and before the borehole was sunk to its present depth.

While this is at the present perfectly apparent, during the progress of boring operations, even when the Permian rocks had been entered upon, the appearance of the material brought to the surface deceived those in charge of the work, as it seemed to indicate that the greensands of the coal-measures were still being passed through—that is, the rocks were of the same colour and grain as those of the coal-measures, only much harder. This in some measure justified proceeding to further depths with the borehole; but, as these strata belong to the Permian series, all hope of finding coal under them has vanished.

The lignite-beds worked near Waimea Station for home-consumption are of the same age and quality as those at Switzers, at the Mataura Falls, and elsewhere in the Southland District. Calcareous greensands full of casts of fucoids overlie these lignite-beds along the lower course of the Waimea River, and in the neighbourhood of an outcrop of the lignite. Mr. McKay supposes that these greensands should underlie the Waimea calcareous sandstone on Longridge Creek, which would involve the reference of these lignites to a formation of greater age than the Miocene. This difficulty has already been referred to, and without making it quite clear what actually is the age of the beds, so that further survey must be undertaken in order to settle this question.

WAKAMARINA GOLDFIELD.

During February last Mr. McKay was sent again to examine the Golden Bar Quartz-mine, situate at Dead Horse Creek, on the right bank of the Wakamarina River, between Deep Creek and Dome Creek.

The reef is of a good workable thickness—4ft. to 6ft.—and the samples brought to the Colonial Museum yielded gold in the laboratory at the rate of 5dwt. 3gr., 4dwt. 19gr., and 2dwt. 4gr. respectively. It must be confessed that the yield will have to improve before the mine can be said to be payable. An improvement in this respect may be looked for, warranted by the well-known richness of the alluvial ground in the vicinity, and lower down the Wakamarina Valley.

The remarkable thing is that no rich reefs have yet been discovered, and that defined fissure-lodes are comparatively rare in the Wakamarina Valley, provoking the speculation as to whether the bulk of the gold obtained has not been derived from some other source than reefs of the ordinary type and character, and perhaps, as I have described in the case of the Blue Spur, Tuapeka, from an auriferous cement faulted among the older rocks, and which has still to be discovered.

AUCKLAND DISTRICT.

During March and April Mr. McKay visited various places in the northern part of the District of Auckland : first, Pakaraka and neighbourhood, for coal; secondly, the Puhipuhi Silverfield; thirdly, the Kaeo Valley and vicinity of Whangaroa, for coal, &c.; and, fourthly, the vicinity of Mongonui, for the same purpose.

Pakaraka and Vicinity.

The anticipated failure of the Kawakawa Mine has given an impetus to the search for coal in this district. Boring for coal has for some time been in progress a mile to the westward of Turntable Hill; but here the depth is likely to prove considerable before the coal, if present, could be reached. As yet the depth sunk, 47ft., has not more than passed through the alluvia, and the first rock of the coal-bearing series will prove either the lower beds of the flinty firestones under the hydraulic limestone, or the higher beds of the greensands underlying. In the same neighbourhood, and equally proving the same area, a more advantageous site might be selected, at which the depth to be bored would be greatly less, and I should not, therefore, recommend that this bore be proceeded with.

At the eastern base of Turntable Hill the greensands forming the cover of the Kawakawa coal show but moderate thickness. Some prospecting has been done, and traces of coal have been found on this side of the hill. It is quite a matter of uncertainty whether at this place a workable seam be present; but, at all events, to prove this one way or other would or should not be a costly matter.

The greensands and underlying strata to the lowest beds of the series from Turntable Hill strike N.W., and at first rest on the range of old rock bounding Scoria Flat and the valley of the Kawakawa River to the north. On the north side of the range a swampy valley cuts off and isolates a low range from the main body of hilly country to the east and south. This range of low hills trends north-west and south-east, and, lying eastward of the main road to Ohaeawai, is terminated before reaching the road from Pakaraka to Black Bridge, on the road to Waitangi. The north-eastern lower slopes of this range show the presence of Palæozoic rock as green or grey aphanite and diorite sandstones, probably of Devonian age.

On these, and dipping to S.W., rest grey and brownish soft sandstone passing upwards into dark-grey or green soft sandstones, which are slightly calcareous, and at many places contain an abundance of minute fossils. The higher of these beds are more calcareous, and represent the Whangarei limestone, which, however, is nowhere characteristically developed in this range of hills.

On the crest of the range, and also on its lower slopes close to the main road, the firestones and flinty beds that underlie the hydraulic limestone in most parts of this district are clearly exposed in conformable succession. Following the section upwards, these are the last rocks of the coal-bearing sequence that can be seen, since the low grounds to the west and south-west are covered by lava-streams and other ejecta from Paeroa and the neighbouring volcanic cone to the east of Paeroa.

There can be no doubt that the younger sedimentary rocks here described belong to the Kawakawa coal-bearing series. This is shown by the superposition of the firestone and flint beds on the lower part of the series at this place. It is more difficult to determine the certainty of there being workable seams of coal under the greensands at this place. At the surface, although careful search was made at many places, no very decided indications could be found, and the probability is that no coal-seam of any considerable thickness exists; but the soft sandstone breaking down rapidly tends to obscure any outcrop that may occur. By a properly-placed borehole the whole of the Pakaraka Flat might be proved also, and a successful issue to such an undertaking would be of great consequence not only to the Bay of Islands district, but to the whole of the northern district of Auckland.

Further to the north-west, on the banks of the Ngahikunga River, joining the Waitangi at Black Bridge, the Whangarei limestone appears at two places. In these places this limestone is characteristically developed as a subcrystalline flaggy limestone, with thin partings of greensand. The underlying rock is not seen at either outcrop; but in the hills to the north, towards Waimate, the firestones and flint-beds overlie, and have in that direction a very considerable development. Following the river upwards, there is in this direction an equally massive development of the overlying beds. Above the bridge leading from Pakaraka to Ohaeawai and Waimate the last-mentioned rocks are in the banks of the stream generally of a dark-grey colour, but elsewhere, where exposed long to atmospheric influences, they are of a light-grey colour, almost white.

North-west of Paeroa Mountain, in the bed of the river, hydraulic limestones succeed and overlie conformably the firestones. The limestone in its lower beds has bands of bright-green sandstone and darker shaly beds, which latter contain septaria, often containing fragments of Inoceramus shells, and occasionally nearly perfect specimens.

Marly hydraulic limestones close the section as far as seen, these being overlain and obscured by volcanic rocks from Paeroa.

Nowhere in this section are the lower beds of the sequence under the Whangarei limestone exposed, and the presence of coal-seams would most readily be proved by a borehole at, or a little lower down the river from, the outcrop of the Whangarei limestone. It has been supposed that the greensandstone interbedded with the lower part of the hydraulic limestone indicates the near presence of coal; but this is an error, arising from not recognising the existence of two or more developments of greensands in the sequence of the Cretaceo-tertiary strata of this part of the North Auckland District. In this section the coal is not likely to be reached at a less depth than 300ft. from the surface, and its existence is somewhat problematical.

South and south-west of Paeroa, within the watershed draining into the Kawakawa River, there is a considerable development of limestones underlain by greensands, followed to the south and west by siliceous shales that cover a considerable area of country on the southern side of this watershed.

Further down the same valley the limestones again appear, dipping to S.; and from beneath these the greensands appear in the wooded range in the direction of Turntable Hill. No coal is known outcropping anywhere in this direction, but it is quite probable that a discovery may be made along the outcrop of the greensands farthest north.

While at Pakaraka Mr. McKay collected samples of the supposed auriferous scoria from Paeroa, and by grinding and washing endeavoured to detect the presence of gold on the spot, but without success.

The method of treatment followed consisted in grinding the whole material so finely that all the non-metallic mineral matter of the specimen capable of suspension in water is thus got rid of without current-washing and the removal of sand-grains, as in ordinary pan-washing. When the material is reduced to such minute quantity that it can be conveniently treated in an agate mortar, it is transferred, and ground till the whole of the quartz or other matrix is removed, and the most minute particles of gold are flattened out, so as to be easily discerned. The metals and metallic compounds remaining, other than gold, are next removed by means of a little acid, and if gold be present it can then be detected by the eye at the bottom of the mortar. If carefully conducted, this method of testing is sufficient for the detection of far more minute quantities of gold than by the usual methods of analysis.

Samples of the same material were analysed in the Colonial Laboratory, but yielded no gold; and, judging from the appearance and character of the stuff, it would be somewhat surprising if it did.

Paeroa, one of the most perfect volcanic cones in the North Auckland District, is one mile south of Pakaraka. I thoroughly examined it in 1866, and it was again visited last year by Mr. McKay. By barometric measurements it was ascertained that the height of the cone is about equal to the present depth of the crater. The mountain rises 640ft. above the level of the Pakaraka Plain, and 500ft. above the downs and low scoria hills at its base. The crater at the top is about a third of a mile across, and not more than 50ft. at the bottom. On the north-east and east sides the walls of the crater are very abrupt, but on the western and southern sides the slopes are such that by aid of the bush clothing its sides the bottom of the crater can be reached. Though far from being the largest, this is in other respects the most beautiful and remarkable of all the crater-cones in New Zealand. The symmetry of its external contour is only rivalled by Mount Rangitoto, in the Hauraki Gulf, at the entrance to Waitemata Harbour. Only on the southern side has the perfect equal height of the crater-rim been broken and lowered—probably during the last eruption. This aspect of the mountain, not being visible from ordinary lines of traffic or travel, is seldom seen, and it is not generally known that there is a breach on this side, so that little more than half the total depth of the crater is perfect on that slope. The interior of the crater is no less beautiful, the funnel-shaped opening gradually contracting to the diameter mentioned, while the sides are luxuriantly clothed with a variety of native trees, shrubs, and ferns. Perhaps the most remarkable circumstance connected with this volcano is that it has been built up from the level of the old plain without the slightest disturbance to the base on which it rests or to the material of which it is composed; and, the depth of the crater being equal to the height of the cone, inside or out at no great distance from the present surface the sedimentary rocks on which the whole superstructure is built up might be reached.

There is within a distance of about two miles from the northern base of the mountain a thick deposit of quartzose gravel or conglomerate belonging to a Tertiary formation; and this, it may be, extended over the site of Paeroa before the first eruptions commenced, and from this may have been derived the inclusions of quartz which are so frequent in the scoria surrounding the base of the mountain on the north and east sides. These inclusions also might contain traces of gold, and hence may have originated the idea that the scoria itself is auriferous.

The main features of the geological structure of the district were shown on my map published in 1866, and again in the nineteenth volume of the Geological Reports, 1887–88, with a report by Mr. McKay. A special coloured map has been lately prepared, in which the formations are drawn on the latest county map. This is not yet lithographed, but the following notes that will accompany it will serve to explain the geology of the district:—

Palæozoic Rocks.—These lie to the east and north-east of the area coloured on the map. Coal, greensands, and volcanic rocks are usually in contact with these Palæozoic rocks; but Tertiary strata unconformable to the Cretaceo-tertiary series may also be so.

Greensands and Coal-bearing Strata.—The north-east mass of these shows the beds dipping S.W., or away from the Palæozoic rocks; and it is towards the eastern side of the greensand areas that coal outcrops should be looked for. In the southern part of the larger eastern area the country is hilly and deeply cut into by gullies. These gullies should be examined for probable outcrops of coal. Coal found in any of the greensand areas would in all likelihood extend west and south-west under the other divisions of the Cretaceo-tertiary series, coloured blue and light-green on the map.

Whangarei Limestone.—This rock is not in itself a strong proof of the presence of coal within the area in which it is found. It often occurs that where the Whangarei limestone is present the coal is thin, or absent altogether. This limestone is, however, of great service in determining the identity of greensands that underlie as being, or belonging to, the true coal-bearing lower portion of the Cretaceo-tertiary series.

Firestones and Hydraulic Limestone.—Where these rocks are present no coal is to be expected showing at the surface, and generally the depth of a shaft or borehole would be so great as to render such methods of proving the presence or absence of coal very expensive, and such a work should not be undertaken unless a good workable seam has been shown to be present in the adjoining greensands.

Tertiary Rocks.—These occur only in the northern part of the area coloured on the map. They are seen to overlie the Whangarei limestone, and thus are shown to be unconformably younger than the rocks of the Cretaceo-tertiary series.

Volcanic Rocks.—In the northern and central parts of the area coloured on the map these rest on the Cretaceo-tertiary beds, or on the Palæozoic strata, as a comparatively thin covering, and nearly obscure these underlying rocks.

Puhipuhi Silver-mine.

This district was visited by Mr. McKay in March, 1890; but the weather was so bad that no satisfactory observations could be made. In 1866, during my geological survey of the North Auckland District, I made a section through this district, which, as published with the map, distinguished the following formations from east to west: 1, Diorite slates; 2, clay-slates; 3, cherty or siliceous slates; 4, diorite and feldstones in heavy dykes; 5, white feldspathic slates; 6, massive diorite and aphanite breccias; 7, purple clay-slates. These rocks decompose with great facility, and the argentiferous lodes occur in the decomposed green aphanite, which is strongly charged with pyrites, and has been converted into a tufaceous sandstone.

The formation containing the silver-bearing lodes corresponds with No. 6 of the above section.

The area within which are most of the reefs at present being prospected lies to the east of Ruapekapeka Hill, and is bounded to the west by Cretaceo-tertiary rocks covering all the low grounds in that direction, and to the north-west and east by volcanic rocks. To the eastward the volcanic rocks form a high table-land, and constitute the central part of Puhipuhi Forest. From this table-land the slope to the westward is abrupt, and on this side, from under the volcanic sheet, the silver-bearing rocks are exposed, first as a steep slope broken by gullies, and afterwards, more to the west, as rugged hilly country, gradually descending to the lowlands. The drainage of this part of the country falls to the Wairoa River. The reefs are best exposed close under the steep edge of the volcanic plateau on the east, the originally hard green aphanite sandstone being decomposed to a considerable depth from the surface on the spurs and steep slopes; but the rocks in their natural state can be examined along the channels of the different creeks that have cut deeply into the country. The decomposed rock forms generally a white clay, in which no metallic sulphides can be detected, but the rocks are, however, frequently stained from the presence of iron-oxides. The reefs in most instances extend in a northerly direction, but that known as Prospectors' No. 1, the richest known at the time of Mr. McKay's visit, has a direction nearly east-and-west.

The quartz of the silver-bearing reefs is somewhat peculiar in character, and not easily confounded with the heavy lodes of blue or grey pyritous quartz that are common to this formation wherever it is present in the North Auckland District. The colour of the lode-quartz is usually a light grey, and in some of the lodes it is a solid, compact, amorphous, or but slightly granular or crystalline stone.

Often towards the hanging-wall the stone is composed of plates of quartz, of which the outer surfaces are covered with minute crystals of quartz. This tabular crystalline form of quartz is considered a good indication of the near presence of silver-ore, but the ore is rarely found in this form, its tendency being to appear in the more solid quartz forming the base on which this tabular variety is supported.

With these lodes are often associated heavy banks of cherty quartz, and to the north and west of Puhipuhi the formation contains intrusive masses of diorite. At many places the rocks are of a ferruginous-red colour, and contain jasper, in which, from infiltration of quartz, the argillaceous portions of the formation have been converted into jasperoid slates. The green tufaceous rocks under such circumstances are usually of a more calcareous nature, and are associated with igneous rocks, the vesicular cavities in which are for the most part spherical, and are filled with carbonate of lime. Sometimes compact crystalline limestones are developed at this horizon in such solid masses as to be fit for quarrying for architectural purposes or other uses. Excellent ironstones are also found in this formation.

The samples of silver-bearing quartz forwarded by Mr. McKay, and subsequently assayed in the Colonial Laboratory, were obtained from No. 1 lode on the Prospectors' lease, and were taken from a depth of 60ft. from the surface. The samples, in the order of their numbers, were taken to represent—first, the best sample that could be obtained; second, an average sample; and, third, the least productive that might be regarded as a silver-bearing ore.

The yield varied from 352oz. to 65oz. of silver per ton, the average yield being about 200oz. to the ton, omitting some obviously inferior stone. At the time the samples were taken some ten or twelve tons of similar ore was in the paddock, and the lode as mined upon was about 4ft. in width. Most of the silver is present as fine-grained sulphide, and presents no difficulty to its reduction by the ordinary "Washoe" process.

It would be premature to give a decided opinion as to the value of this mine in particular, or of the field as a whole; but, having regard only to the samples that from time to time have reached this office, if these be considered only with respect to the percentage of silver present and the reported thickness of the reefs, the opinion might be hazarded that the field will prove a payable one to work. But there are other circumstances that, apart from the mere percentage of silver, affect the value of the reefs, and place the prospects of this field under a less encouraging aspect. These are the nature of the ore and the manner in which it is disseminated through the stone, and, in this connection, also the character of the stone itself.

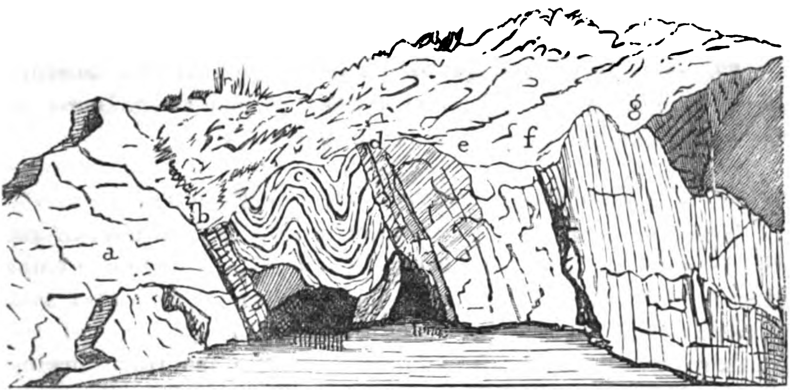
The metallic ore, which is chiefly the arsenical sulphide of silver (proustite) mixed with minute tabular deposits of antimonial sulphide (stephanite), and probably also the mixed sulphides of silver (polybasite), is disseminated throughout the matrix of hard quartz as minute scattered crystals, or more frequently forms bands of hard, darkened quartz, and in this case is so intimately mixed with the quartz that there is no means of concentration to a sufficient degree of richness for profitable reduction on the ground, or for transport to reducing-works at a distance.

The quartz also is of such a character that in most instances it will be costly to reduce it to the required degree of fineness.

No doubt a high percentage of silver would enable all these difficulties to be overcome successfully, and the only question at present is whether the percentage ascertained as the average yield of the stone will be sufficient to enable this to be done.

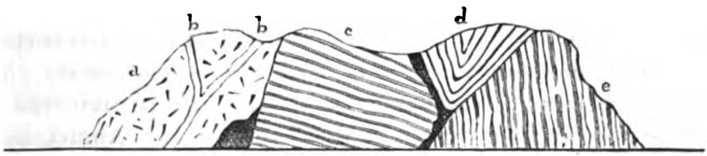
The experiments made in the Laboratory prove that there is no difficulty in reducing 80 per cent. of the silver present by the ordinary "Washoe" process, in which the ore is crushed, and roasted with 8 per cent. of salt and 2 per cent. of iron-sulphate, and then amalgamated. This is not more than the average loss in milling silver-ores in other countries.

The mineralised country extends to the north-west in several parallel lines, none of which, however, are continuous. With the same association of rocks mineral lodes are known at the following localities in the district: On the trail over the range between Wangaruru and Waikari I found masses of reef-quartz; and on the same line northward to Rawati, which is a bay west of Cape Brett, lodes carrying gold and antimony (stibnite) were found many years ago. At Tikiora, south of Russell, is a development of manganese-ore associated with quartz and red jasperoid slates. This ore has been worked since 1872; and it is important to bear in mind that the capping of very rich silver-mines has frequently consisted of manganese-oxides. On the same line of strike as the foregoing is a remarkable lode on Stephenson Island, three miles off the entrance to Whangaroa Harbour. This island is about a mile in length, and 360ft. high; it is composed of diorite sandstone, invaded by dykes that have changed into serpentine, and which decompose into dark-green earthy-like rock, with a greasy laminated fracture. Forming the back to the serpentine is a hard felsite, similar to the rock at Tararu Point at Coromandel; and along the junction is a lode, or vein, 2ft. thick, filled with nodules of quartz and various sulphides imbedded in a feldspathic matrix, and traversed by veins of calcite. Between the quartz-vein and the serpentine is a thick bed of bright-coloured pink-and-yellow tufaceous rock in thin layers (noted at the time, 1866, as ash-beds), and on the serpentine side of this a development of white vein-quartz and manganese-oxides, as shown on the accompanying section, was found :—



The cave, north end of Stephenson's Island. *a.* Felstone. *b.* Quartz-vein with sulphides. *c.* Hornstone slate, contorted. *d.* Cherts. *e.* Earthy serpentine. *f.* White quartz, manganese, and iron-ores. *g.* Diorite slate.

On the same line, at Rangonui Promontory, Brodie's copper-mine is situated, where there was a venture in copper-mining in 1857. The section of the lode-ground is very similar to that of Stephenson's Island, and is shown in the following section:—



Brodie's copper-mine, Mongonui. *a.* Volcanic agglomerate. *b.* Copper-lodes. *c.* Dolerite dykes. *d.* Pink tuff-stones. *e.* Diorite slates.

The copper-ore has been developed in a breccia, or angular conglomerate, consisting of blocks of trachyte and porphyry, cemented with lime-carbonate and a magnesian mineral not determined; and disseminated through the mass are grains and crystals of iron- and copper-sulphides, and in some parts grains of metallic copper. The conglomerate forms a cliff about 300ft. high; and for about 50ft. the green hue formed by the surface incrustation of silicate and carbonate of copper gives the cliff a most conspicuous green colour from the seaward.

Fifteen miles further north is Mount Carmel, the peninsula which forms Ohora Harbour. It consists of a similar development of diorites and tufaceous sandstones with mineral impregnations; but no mineral lodes were discovered. Again, at the Reinga, between the North Cape and Cape Maria, the same green diorite rocks occur, and are decomposed to yellow clays, with the formation of quartz veins that carry gold. South of Puhipuhi the same mineralised formation is to be recognised in the manganese-lodes of Waipu and the copper-lodes of Kawau.

The width of the mineral belt is very considerable—probably about twenty miles—as, for instance, between Cape Brett on the north-east and Kawakawa on the south-west.

Kaeo Valley, and Vicinity of Whangaroa.

Traces of coal have been known to exist in this part of the district since the very early days of the survey—first, near Cape Horn, on the north side of Whangaroa Harbour, and also near One-tree Hill, on the watershed between the Takau and the southern branch of the Kaeo River. Near Cape Horn boring was carried on for some time, and a borehole was sunk on the shore-line to a depth of nearly 100ft.; but on a survey of this part of the district being made by Mr. McKay in 1879 it was ascertained that the disposition of the strata was such that ordinary prospecting of the natural exposures afforded a more effective means of finding coal, and since then no further attempts have been made to find coal by boring. Although the rocks present belong to the period of the principal coal-formation of New Zealand—the Lower Greensand and Cretaceo-tertiary formations—only mere traces of coal have been found. The highest bed present that can with certainty be referred to the Cretaceo-tertiary period is the hydraulic or Amuri limestone. The brown sands stretching across the lower part of the Kaeo valley, and also present eight or nine miles further inland in the valley of the northern branch of the river, were formerly referred to the marly greensands under the hydraulic limestone, and consequently it was thought coal-seams might occur immediately under these. Certain fossils—notably a large species of Cardium—were considered to be a further proof in support of the probable occurrence of coal under these beds; but Mr. McKay's late examination leads him to the conclusion that these Kaeo sandstones are younger than the hydraulic limestone. The proofs in support of this conclusion are given at length in his detailed report on the district. There is, however, some uncertainty as to the actual relation of these beds to the hydraulic limestone; but Mr. McKay is inclined to believe that the two are conformable to each other, and that the Kaeo sandstones most likely represent the greensands that in the Kawakawa section overlie the hydraulic limestone, and which are supposed to be the equivalent of the Weka Pass greensands of the general classification.

The hydraulic limestone is present in different parts of the district, and was noted at the following places: (1) At Totara, on the north side of Whangaroa Harbour; (2) between the Pupuki and the Kaeo Rivers, on the road from Totara to Kaeo Township; (3) in the Kaeo valley, half a mile above Kaeo Township; (4) in the north branch of the Kaeo River, at Shepherd's farm; and (5) east of St. Paul's, and thence extending to within two miles of the coast-line south-west of Stephenson's Island.

Below the limestones are firestones and dark shales, with concretions containing fossils (Ammonites and Inoceramus); and it was in these beds at Totara that boring for coal was carried on. Underlying these beds there is developed in the Pupuki valley a great thickness of sandstones and dark shales, alternating as beds 6in. to 18in. in thickness.

The coal of One-tree Hill, between the upper south branch of the Kaeo and the Takau watershed, turns out to be an altered lignite occurring at the base of the volcanic series, and is therefore referable to the Post-miocene period of volcanic outburst in this part of the North Island.

Coal at Cooper's Beach, Mongonui.

The lignite-deposits at this place were examined with the object of determining whether petroleum-shales of any value are associated with these beds. As far back as 1866 a sample of an oil-bearing mineral was forwarded to this office by the late Rev. R. Taylor, and this, on analysis in the Colonial Laboratory, yielded oil and gas at the rate of over 80 per cent.

The specimen yielding this result was obtained as a fragment on the beach, and there has since been an uncertainty as to whether it was originally derived from the beds there showing *in sitû*, or whether it was a drift specimen derived from a foreign source.

The samples obtained *in sitû* on this occasion are not equal in quality to that first found, but yet are oil-bearing to a greater extent than most of the similar deposits in New Zealand. The results of the analysis made in the Colonial Laboratory are as follow:—

Fixed carbon	11·17
Hydrocarbon	33·18
Ash	41·04
Water	14·61
	100·00

The original specimen, forwarded in 1866, gave the following results:—

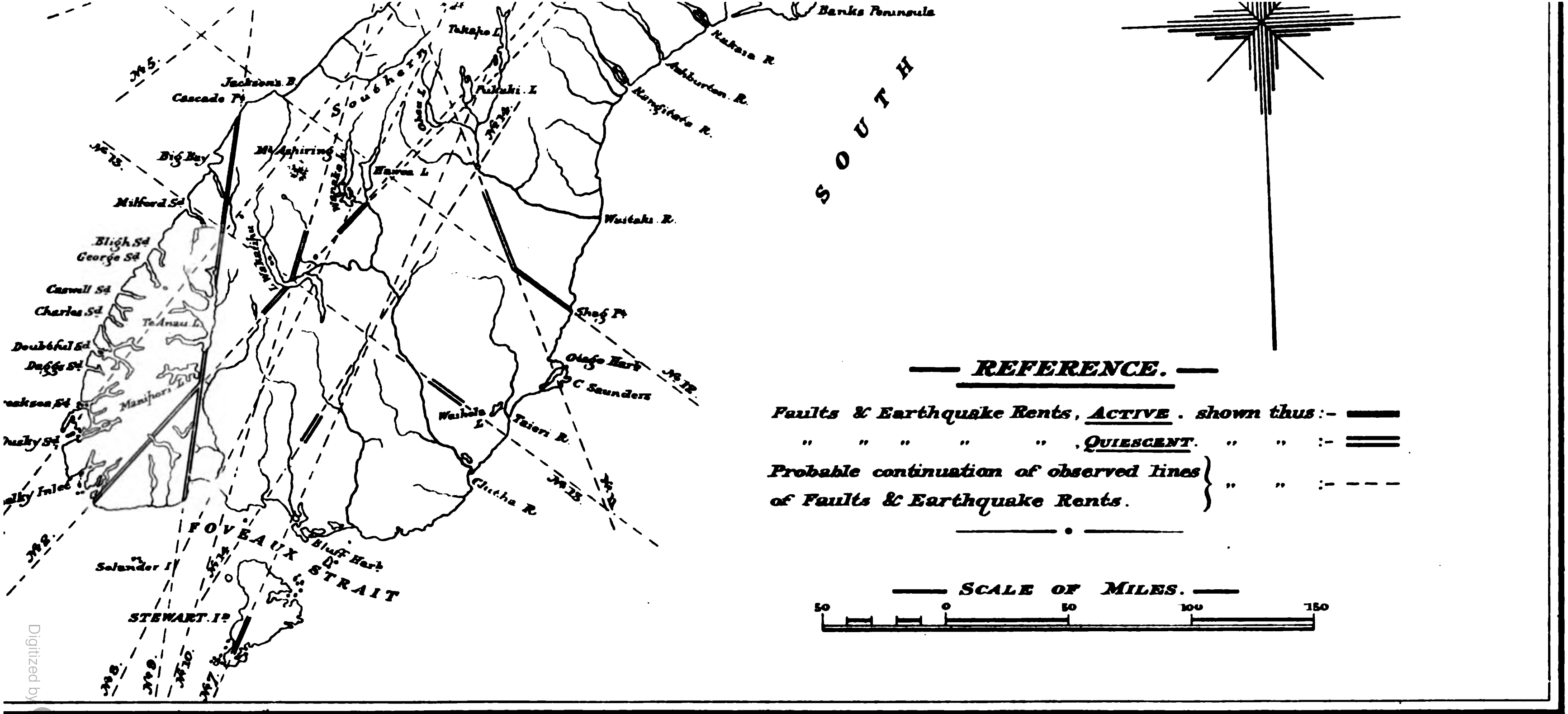
Fixed carbon	9·80
Hydrocarbon	75·20
Ash	13·70
Water	1·80
	100·00

There are several small seams over and above the principal deposit of shale showing in the cliffs of Cooper's Beach, and it is just possible that the first-obtained specimen may have been derived from one of these. These seams occur at the base of the great series of volcanic breccias that overspread a large portion of the North Auckland peninsula. At this place the lower beds are less exclusively composed of volcanic material, consisting also of gravels, sands, and clays derived from various older formations; but the upper beds, as elsewhere, are composed almost entirely of brecciated volcanic material, or tufaceous clays, which, for the most part, are seen to be fine-grained breccias and ash-beds in a decomposed state.

Near the Township of Mongonui these latter beds often contain burnt timber, and where they are cut into by a small creek crossing Mr. McIntosh's farm they have yielded a large number of palm-fruits, of which a fine collection was made when the beds were last examined.

JAMES HECTOR,
Director.

Wellington, 31st July, 1891.



Banks Peninsula
Kakaia R.
Ashburton R.
Rangitata R.
Takapo L.
Pukaki L.
Ohau L.
Jacksons B.
Cascade Pt.
Southern
Big Bay
Mt. Aspiring
Hawea L.
Wanaka L.
Milford Sd.
Waitaki R.
Bligh Sd.
George Sd.
Caswell Sd.
Charles Sd.
Te Anau L.
Doubtful Sd.
Daggs Sd.
Manipori L.
Dusky Sd.
Shag Pt.
Otago Harb.
C. Saunders
Waihola L.
Taieri R.
Clutha R.
Bluff Harb.
FOVEAUX STRAIT
Solander I.
STEWART I.
SOUTH
No. 5.
No. 15.
No. 12.
No. 13.
No. 8.
No. 9.
No. 10.
No. 7.
REFERENCE.
Faults & Earthquake Rents, ACTIVE. shown thus :-
" " " " " , QUIESCENT. " " :-
Probable continuation of observed lines of Faults & Earthquake Rents. " " :-
SCALE OF MILES.
50 0 50 100 150

ON THE GEOLOGY OF MARLBOROUGH AND SOUTH-EAST NELSON.

REPORT BY ALEXANDER McKAY, F.G.S., ASSISTANT GEOLOGIST.

PART II.

[For Part I. see "Geological Reports," Vol. xx., 1889, p. 85.]

Wellington, 1st September, 1890.

THE physical features of the Marlborough and Amuri district have been sufficiently indicated in the first part of this paper, and in the Geological Reports for 1885, dealing with much the same area of this part of the South Island, and it but now remains to show how, in all probability, and during what geological periods, the present features developed themselves.

That the land-surface of what was New Zealand in pre-Cretaceous and post-Jurassic times was in parts highly mountainous is sufficiently indicated by the character of the strata forming the base of the Lower Greensand and Cretaceo-tertiary formations; and that the mountain-chains then, as now, were linear in a north-east and south-west direction is equally probable. It does not, however, follow that the Southern Alps extended their highest elevations along the same line that they now do, or that other sub-parallel ranges which at the present time almost rival the Southern Alps in height had as mountains their present importance, if, indeed, any existence at all.

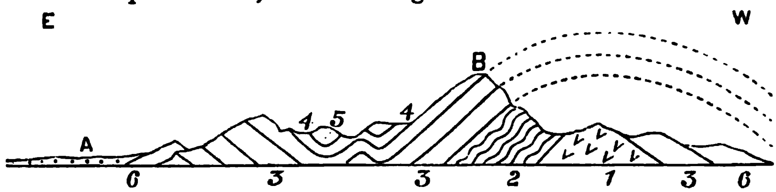
That then, as now, subject to modifying causes, the rivers would tend to take as short and direct a course as possible to the sea is a matter of easy inference; and that some of our river-valleys may have existed since that distant period is possible, and may even be considered as probable, since, in some respects, the valley of a great river has the property of permanence in a greater degree than the mountain-range on the flanks of which it was originally excavated.

At the period referred to land probably extended far to the eastward of the present limits of these Islands, as it certainly did to the south and south-west, connecting the southern extension of these Islands with the Auckland and Campbell Islands, and even, to the eastward, the more distant Chatham Islands. To the westward the evidences of land-extension are less clear and decisive, more especially in the south-west, where deep ocean-waters lie at no great distance from the coast-line; yet there is great probability that farther to the north the land extended considerably to the westward of its present limits.

The main geological axis of the South Island lies along the western base of the Southern Alps, the Southern Alps themselves being only the eastern side of an anticlinal upheaval, the western side of which has been displaced to a lower level or removed by denudation.

New Zealand geologists generally have explained the present features of the western slope of the Southern Alps as having been brought about wholly by the action of denudation, either subaërial or marine, or both combined. These agencies, it is supposed, acted with greater force on this side, and gradually reduced the western flank of the range to sea-level, and at the same time the central granitic axis of the main anticlinal, and so far encroached on the eastern wing of the great anticline as to leave the granitic axis apart and distinct from what now remains of the original. Again and again have the Southern Alps been described as forming part of a huge anticlinal the western half of which has been removed by the action of the sea.

This "huge anticlinal" was originally built up of, and now shows the presence of, the following rock-formations:—



1. Granite. 2. Schists and other metamorphic rocks. 3. Carboniferous and, possibly, at places, Devonian rocks. These appear on both flanks of the mountains. On the eastern slope of the mountains we have in addition—4. Permian and Jurassic rocks. 5. Liassic. And, again, on both flanks of the range—6. Cretaceous and Tertiary rocks.

The above may be taken as an ideal section from the Canterbury Plains twenty-five miles south of Christchurch, to the west coast at the mouth of the Totara River. The illustration might equally apply to a line from the Canterbury Plains along the Ashburton or Rangitata Rivers, or, further south, across the southern part of the Canterbury Provincial District. In the two first-mentioned variations of the line the section would end in the vicinity of the Okarito, where there are neither Maitai nor Cretaceous and Tertiary rocks to the west of the crystalline rocks, but further south, between the Paringa and the Haast River, both these formations are again present, as shown in the section.

The theory of the great anticline, shorn of its western half and the higher elevations of its eastern slope by the ordinary process of denudation, has to explain the presence of Maitai rocks along the low grounds of the western side of the present mountain-chain and west of the belt of crystalline rocks forming the core of the anticline.

The late Sir Julius von Haast saw this difficulty, and to avoid it established what he called the Westland formation ("Geology of Canterbury and Westland," p. 256); but the strata comprehended under the term, and developed along the lower slopes of the Southern Alps, are, I believe, by the Geological Survey rightly included with those of the Maitai series. At all events, except where altered by the intrusion of plutonic rocks, they are not different in character from those forming the crest of the main range to the eastward.

Von Haast, however, believed that the orographical features of the greater part of the South Island are of very ancient date, and, consistent with this idea, the erosion of the western half of the great anticline should have taken place prior to the deposition of the Westland formation, or, otherwise, the dip of the Maitai beds on the west wing would require to be such as would bring them into the position in which they are now found, which, to say the least of it, is improbable. Again, although the Cretaceo-tertiary and Tertiary rocks of the Westland District are found some distance island, and at Kanieri Lake are deeply involved close to the granite, it is not clear that they rest on the granitic rocks of that part, and it will have to be considered whether the great scarp of the western side of the Southern Alps was formed when the deposition of the coal-bearing strata of the Grey and Buller coalfields was in progress.

On the supposition that the abrupt slope of the west side of the Southern Alps is not wholly, but in part only, due to denudation, and that it is largely due to the existence of a line of fault running along the base of the mountains, we may have an explanation in harmony with the facts, and in accordance with another set of facts that determine the geological period during which great and important changes in the physical features of the South Island were effected.

In the district of the South Island forming the subject of this report the Tertiary strata are confined to two distinct and widely-separated areas—firstly, to the northward, to the lower valley of the Awatere River, and along the coast to the east side of Lake Grassmere, and thence south to the southern limits of the Flaxbourne watershed; secondly, to the south-east part of the district between the Conway and the Hurunui Rivers.

There is no evidence to show that Eocene or Miocene rocks ever extended over the intervening parts of the district, embracing an area of over two thousand square miles; but in the late Pliocene or during the Post-pliocene period detritus from the southern area of Tertiary rocks was spread over the district east of the Inland Kaikouras from the Charwell (a branch of the Conway) to Cape Campbell.

The deposits of this date, of which the derived Tertiary rocks form no inconsiderable part, are sometimes rudely stratified, but usually have the character of a mixture of glacier morainic matter and more or less well-rounded river-gravels. Nowhere have they the character of marine deposits, and the faint indications of marine shells found at one or two places in the higher beds may be due to derived shells from an older formation. On the whole it is a drift formation, and the evidence is conclusive that the drift of the material was from south to north, or from the south-west to the north-east. The fossils of the Tertiary rocks of the Mason watershed and Lottery Creek have found their way north-east to the Kahautara valley, on the south-east side of the Looker-on Mountains, and also across the intervening space that separates the Tertiary rocks *in sitû* from the Middle Clarence valley. From the Gore River to the upper part of the Ure valley abundance of Tertiary fossils, derived from the rocks of Lottery Creek and the Mason River, may be collected at almost any point where these Post-miocene conglomerates have been preserved and exposed along the Great Fault line where this is cut across by the numerous small rivers draining the south-east slopes of the Inland Kaikoura chain of mountains.

Beyond the Ure watershed the same drift continues to the north-east, and is last seen in this direction within a few miles of Cape Campbell, where it occurs at a height of 800ft. above the sea.

The same conglomerates are, as has been described, largely developed along the coast-line between the Lower Clarence and the Flags River, and, more inland, along the lower slopes of the Saw-tooth Range and Front Hills. In Deadman's Hill and in the gorge of Shades Creek there is an excessive abundance of Tertiary blocks, and of great size, in these conglomerates, mixed with the rocks of the central higher part of the Inland Kaikouras.

There are no Tertiary limestones in the Awatere valley, nor anywhere over the fossiliferous area to the east and south-east connected with this. Consequently, the limestone blocks found in the Upper Ure could not have drifted south or south-west from that quarter. *Dentalium solidum* and the genus Flabellum are not known in the Awatere and Flaxbourne rocks, and, consequently, the conglomerates of Deadman's Hill came from another direction. North-east of Tapuaenuka the rocks of crystalline intrusive dykes so abundant in that part of the range form a large part of the conglomerates to the north-east and east, but are less abundant as we proceed up the Clarence valley, and are scarcely noticeable after passing the Bluff River, such igneous rocks as are present here and further up the river being derived from the volcanic rocks of Gridiron Hill and the Warden. It were useless to recapitulate further. Enough has been said to show clearly that the Post-miocene conglomerates drifted from their source to the north and east, and in so doing, if the present barriers existed, would have to pass mountain-ranges to invade the valleys of the Middle Clarence and the Ure Rivers.

It is possible that the rocks of the Whale's-back and Mount Cookson might be carried through the Palmer and Conway Saddles into the Clarence valley, but under present conditions it is not conceivable by what agency. Yet these rocks have been so carried, probably by the current of a large river; and to explain the facts we have to suppose the drainage of the whole of the south-west part of the district was gathered into one stream, which traversed the eastern part of the district in a north and north-eastern direction.

But this theory, to be correct, necessarily supposes that at the time the relative levels were such as to admit of the drainage of the southern part of the district making its way north-east to the different localities mentioned. Under such a state of things the Looker-on Mountains could not have been elevated as they now are, if, indeed, they had any existence at all. The high lands lay to the south and west, but the greater area of the Marlborough Provincial District could not have had the mountainous character that now distinguishes that part of the north-east district of the South Island.

Changes in the relative levels of this part of the district have taken place, and these have been of such a magnitude that we may very safely suppose that a vastly greater area was to some extent affected by the movements going on at the time, and it is not unreasonable to suppose that the Southern Alps give evidence of having been raised or depressed at the same time, and by the same agencies and mode of action.

There is yet another set of facts, which have been described in the foregoing part of this report, which makes it yet more evident that the Marlborough District has not always been a mountainous region, and that its present distinguishing features are of comparatively modern date. I refer to the evidence afforded by the distribution of the rocks of the Lower Greensand and Cretaceo-tertiary formations. These are found at intervals along the coast-line from the mouth of the Hurunui to Amuri Bluff, and along the flanks of the Seaward Kaikouras, or Looker-on Mountains, from the Upper Conway to the north-eastern end of the Saw-tooth Range.

These two areas may be said to unite in the Kaikoura Peninsula. It is true that there are twelve miles of coast-line between Amuri Bluff and Kaikoura Peninsula within which these rocks are absent, but every geologist must agree that at the two places the calcareous rock known as the Amuri limestone was deposited in a connected area and continuously. In the Middle Clarence valley the same rocks begin near the junction of the Gore with the Clarence, and as a narrow belt continue forty miles to the north-east, after which in Benmore they unite with the rocks of the coastward side of the Looker-on Mountains, and this time without a break in their continuity; and, thus united, the same rocks are continued to the shores of Cook Strait between Lake Grassmere and Cape Campbell.

There is also, as shown on the map accompanying, and as described in the first part of this report, a considerable development of the same formations in the Middle Awatere valley, and there is also, near Picton, a small area of coal-bearing rocks that are referable to one or other of these formations. The lower beds are sandstones and shales that might accumulate under somewhat varied conditions, and may therefore be of little value as proving the broadly-extended and continuous character of the formation; but following these there is a great development of basic volcanic rocks, which in the Middle Clarence valley occur between the Bluff Creek and the Gore River and in Warden Hill, each of which attains a height of more than 4,000ft. Opposite these, in the Middle Awatere valley, there is also a great development of volcanic rocks, which in Mouat s Look-out, between the Tone and the Winterton tributaries of the Awatere, reaches a height of 5,300ft., and seems to be the centre of eruption for the tufas, &c., which extend down the Awatere valley, and also the like deposits in the Clarence valley.

The distance from Mouat's Look-out of the volcanic rocks in the Clarence valley is not greater than the same rocks have reached down the Awatere valley, and, as appears evident, there is every probability of the Clarence and Awatere rocks having been erupted from the same source as continuous streams. This possibly could have happened with the intervention of the Inland Kaikoura Range, as at present; but it is much more likely that at the time such did not exist, and that no serious barrier interposed to prevent the lava-streams flowing east as far as Warden Hill, in the Clarence valley.

The next group of beds, the saurian beds and concretionary greensands, in character vary but little wherever they occur, and give evidence of a continuous and widely-extended deposition. It is true that in the Middle Clarence valley they alter their general character somewhat, and, as alternations of sandstones and shales, form a considerable thickness of strata. In the Awatere valley also they are represented by tufaceous beds and volcanic breccias; but, considering the nature of the rock underlying, and in the Awatere valley overlying also, such variations might be expected.

It is the next succeeding division of the Cretaceo-tertiary series, the Amuri limestone, that shows most conclusively the uniform and wide-spreading character of these formations. Scarcely anywhere is the Amuri limestone different in character from what appears in the typical locality at Amuri Bluff. In North Canterbury (Waipara and Weka Pass sections), at Amuri, Kaikoura, and thence to Cape Campbell, it is everywhere the same. Nor is it different where it may be examined at the south-east base of the Looker-on

Mountains, or in the deep narrow valley between these and the Inland Kaikouras, or at any point where present in the Awatere valley; clearly showing that it was not deposited in widely-separated bays and fiords, as its present occurrence at many places might indicate. It is needless to attempt to show that this rock could not have accumulated in such conditions as the valley of the Middle Clarence submerged would present, or as that of the Middle Awatere could afford.

Clearly, then, at the close of the Cretaceo-tertiary period, and when the deposits of that period had appeared as dry land, there were no indications of the present Looker-on Mountains or of the Inland Kaikoura chain of mountains. And if it may be safely affirmed that the Amuri limestone must have been deposited in a sea continuous and connected, in which conditions were uniform as the deposits accumulated, and which presented no excessive inequalities of depth, then what applies to Marlborough and the south-east district of Nelson has application also to almost the whole of the South Island north of a line drawn from the mouth of the Rakaia to Hokitika; and, this much admitted, it is difficult to see why the area should not be extended so as to include the lithographic limestones of the Paringa River and Abbey Rocks, south-west of Mount Cook.

Whether, at the time of the deposit of the Lower Greensand and Cretaceo-tertiary formations, the Southern Alps divided the deposits of this period into two great areas—that of the east coast and that of the west coast—as they are now found, may be doubted; but, at all events, only a narrow and long-extended track of mountain-country would separate the two. How narrow this must have been is shown by the distance separating the outcrops of these formations on each side of the main watershed. The distance between the Wairau valley and the western coal areas is not more than thirty miles; and the coal-deposit at Picton, which may be said to belong to the Wairau valley, is thus within that distance from that of Jenkins Hill, near Nelson, and scarcely more in a direct north-west line to the bituminous shales of Port Hardy, in D'Urville Island.

The same distance separates the Amuri rocks, in the Middle Awatere, from those of the coal-bearing series in the Big Bush, between Tophouse and Nelson. This also is the distance between the Tertiary or Cretaceo-tertiary deposits at the junction of the Wilberforce with the Rakaia, and the coal-bearing rocks near Kanieri Lake; and just about the same distance divides the coal-rocks of the Cameron River, a branch of the Rakaia, from the Tertiary rocks of Ross, on the west coast. Further to the south-west, the distance between the same formation on the east and west coasts of the Island increases, till between Lake Wakatipu and Martin's Bay it is fully fifty miles; but it is less than fifty miles between Mount Eglinton and Martin's Bay.

We have to assume that, before the landward margins of these formations were denuded away, they approached in their east and west limits considerably nearer than they now do, and by so much narrowed the extent of country over which no deposits of this age took place. This will be made more particularly evident by noting the elevations at which the different fragments of these formations are found. Along the southern part of the west coast the coal-bearing rocks attain to no great elevation above the sea; but in the north-western mountainous district of Nelson the higher members of the series reach to between 5,000ft. and 6,000ft. above sea-level. On the east coast the Amuri limestone, forming the higher part of Benmore Mountain, between the Ure and Kekerangu Rivers, has an elevation of 4,900ft.; and in the Awatere valley, on the east slopes of Mouat's Look-out, the lower sedimentary rocks of the series are over 4,000ft. above the sea. In the Trelissick Basin, on the road from Christchurch to Hokitika, they are over 2,000ft.; and they attain a greater height in the Rakaia valley. Between the Upper Ashburton and Mount Potts, near the source of the Potts River, they reach, according to Von Haast, to 5,000ft.

More to the south-west, within the Canterbury District, beyond the Rangitata River, the formation is not present along the flanks of the main range, but lies along the outer slopes of the ranges bounding the Mackenzie country on the east, and is not met with in the interior of Otago (excepting the Cardrona beds, which may be Tertiary) till, in the Shotover valley, in Benmore Mountain, between Moke Creek and Moonlight Creek, they attain an elevation of 3,000ft. above sea-level; and, finally, in Mount Eglinton they are reported to reach a considerable elevation not exactly determined. In Mount Hamilton, more to the east, but in the same district, they are found at an elevation of 3,700ft. If, wherever they occur, these rocks are but fragments of an enveloping deposit which covered all heights lower than the elevations at which they are now found, then it must be evident that they overswept and covered up by far the greater area of the Island east and west of the principal water-parting; and in the northern part of the Island even this must (except the higher peaks) have been submerged.

Thus far and to this conclusion facts and hypothesis alike bring us—viz., that the northern part of the South Island was submerged during the period of the Lower Greensand and Cretaceo-tertiary formations. It may have been that to some extent there was upheaval during Middle Eocene times, as deposits of this age have not been ascertained to occur throughout the district treated of in this report, nor, indeed, throughout New Zealand. Nevertheless, irrespective of any unconformity that may exist between them, Miocene rocks were deposited at many places with seeming conformity on the higher beds of the Cretaceo-tertiary formation, and these, in inland parts, and at high elevations, are found in the valleys of the Waimakariri, Rakaia, and Ashburton, within Canterbury, and at Lake Wakatipu, in Otago; and have been subjected to all or greater part of the movements and dislocations of the older formations.

Another set of facts have an important bearing on the subject of the origination of the physical features of the northern part of the South Island. I refer to the different levels, within limited distances, at which the higher or other beds of the Cretaceo-tertiary formation are found. Whether due to flexure or faulting, when the same beds within the distance of a few miles are in the one case at sea-level and in the other at an elevation exceeding 2,000ft. above it, the conclusion, if instances can be multiplied, is that great changes in the physical features of the country must have taken place. Instances of this are common on both the east and west coasts of the South Island. Benmore Mountain, Marlborough, may be cited as showing this for the north-east district. Big Ben coal-beds, in relation to those of the Selwyn and the Rakaia Gorge, will also serve as examples; while Trelissick Basin, and Redcliffe, on the Rakaia, may be compared with the deposits at the junction of the Wilberforce with the Rakaia, or these latter with the Cretaceo-tertiary and Tertiary deposits in the Lake Heron basin.

Further south in Otago evidence to the same effect is not wanting, as shown in the Shag Point coalfield and along the flanks of the Horse Range; and more to the north-west there is a fine example in the relative levels at which the quartzose sands of the Kyeburn and Mount Burster are found. Further west, the deposits at Cromwell, as illustrating vertical displacement, may be compared with the same beds in the Nevis valley and the Kawarau Gorge; and more to the north the auriferous quartzose drifts on the top of Criffel, with those lying in the Cardrona valley, and showing in the banks of the Clutha River at and below the junction of the Cardrona, may be so compared. On the west coast of the Island instances of this kind are not wanting, but abound, more particularly in the west and north-west districts of Nelson. For instance, compare the same deposits at the Blackball and on Mount Davy with the low-lying deposits of the Brunner coalfield; or the coal-bearing rocks of the low coastal track between the Fox and Ngakawau Rivers, in the Buller district, with the elevated areas of Mount Rochfort, Mount William, and Mount Frederick; or these, again, with the coal-rocks at low levels in the Buller Gorge and to the north-east of Mount William. In the Middle and Upper Buller valleys, and in the valleys of the Mokihinui, Karamea, and Wangapeka, the same class of evidence is abundant everywhere.

In the same connection it is necessary to take into consideration the numberless instances of high dip and involvement of the younger strata between rocks of older date. Examples of this kind are so numerous all over the country that I may very well forbear citing examples, since a study of any particular district will afford a sufficient number of instances.

Whatever may have been the physical features of the country in pre-Miocene times, it is quite evident from what has been already stated that very great changes have taken place since the close of that period; and in the remainder of this report I will endeavour to show that in the production of the present features faulting on a large scale has been an important if not the prime agent.

Subsequent to the elevation of the South Island, during early Pliocene times, dislocations and faulting of the strata manifested themselves along a number of sub-parallel lines. Such of these as have been ascertained to exist within the Marlborough Provincial District and the south-east district of Nelson have been mentioned and described in the previous part of this report (Geol. Rep., 1888–89, pp. 96–99). In recent and historic times these lines have been affected by a continuance of the faulting action. Earthquake-shocks are by no means rare in the district, and sometimes they are of considerable violence. The earthquakes of greater violence which have taken place since the settlement of the district by Europeans have shown their effects principally along the lines of weakness, producing open fissures, or the displacement vertically of the two sides of the fault. Such appearances have usually been regarded as the results of the earthquake or series of earthquake-shocks, which produced fresh fractures, and first drew attention to the existence of these lines of fracture, or earthquake-rents, as they have been called. Displacements of this kind in the Wairau and Awatere valleys took place during the earthquakes of 1848 and 1855, as also happened in the North Island when the earthquakes of 1855 and 1866 took place, and more recently in the South Island, within the Amuri district of Nelson, in 1888. The fissures and displacements thus produced are usually spoken of as being solely due to the particular disturbance of the time when they were first noticed, but by a careful examination of the different lines it is readily ascertained that most of them have only been reopened, and that the latest displacement is but a small fraction of the total resulting from a succession of shocks in times past. A further and closer examination will make evident the fact that no great period of quiescence separates the action last taking place, in historic times, from instances of the same power which have affected the surface at a period prior to the settlement of the country, but which have happened within, say, the last hundred years, more or less.

These very modern displacements are easily traced along the surface by the presence of what either is or has been an open fissure, or by the existence of a sudden drop, producing a kind of sunken wall, which latter form can sometimes be traced to great distances. These fissures and displacements occur in mountain-country, in which denudation acts with great rapidity; and if these evidences of earthquake-action and faulting were not of very recent date, or continually being renewed, it is evident that all trace of them would quickly disappear.

Hence it is evident that the intermittent action of historic times is the continuation of the like prevailing throughout what may be called the modern period. Such evidences, traceable at the surface, can be followed throughout the whole length of the Awatere valley, and from the Flaxbourne River along the Middle Clarence valley to the Gore River, and along a third line of fracture for the whole length of the Looker-on Mountains and of Cloudy Range and Mount Sherwood Range to the eastern corner of the Hanmer Plain. Thence the same line runs nearly due west to the main watershed of the Island. The Awatere line, or lines nearly parallel to it, can be traced as far as the Waiau-ua River. Giving it this extension, this line is traceable by evidences at the surface for a distance of a hundred miles. The Middle Clarence line can be so traced for fifty miles; and the third line, along the base of the Looker-on Mountains, for nearly a hundred miles. In the North Island, also, similar fractures can by surface-indications be traced to long distances.

But it is when we come to examine more closely, and in a strictly geological sense, that the great extension and importance of these fractures are made to appear. Other lines of fracture equally important are in this way shown to exist in other parts of this district, also in other parts of the South Island, and in the North Island as well. Nor is it difficult to show that the influence of these giant faults, as affecting the physiography of the country, has outside it been almost as great as within the Marlborough and Amuri district of the north-east part of the South Island.

It has, I hope, been made clear that in Cretaceous and older Tertiary times the contours of the area of the Marlborough and Amuri district were not so mountainous as to interrupt the continuous deposition of the Amuri limestone between Picton and the Hurunui, and from the east coast west to the Middle Awatere; also that at a later date the drainage of the south and west parts of the district flowed north-east, and deposited evidence of its having done so from Green Hills to Cape Campbell, and from the south-east flanks of the Inland Kaikouras to the sea at Kekerangu. Whether one or several streams were concerned in the deposition of the great Post-miocene conglomerates is not quite clear; but the impression with me is that the conglomerates are mainly the result of the action of one stream, which formed wide and extensive gravel-plains over the area within which the remains of these gravels are now found. It may be, however, that the sea was to some extent concerned in the production of these gravel conglomerates and breccias; but this, as far as the evidence they give of movements subsequent to their deposition, is not of vital importance.

Fault No. 1.

The most easterly of the four great faults affecting the Marlborough District runs out on the sea-coast near the mouth of the Flags River, and is traceable across the south-east spur of Benmore into the lower course of Benmore Stream, within the Kekerangu watershed. The displacement is evidenced by a downthrow of the strata on the east side of the line; but the amount is inconsiderable, being less than 1,000ft., the limestones being still in juxtaposition on each side of the line.

In the lower part of Benmore Stream the drop on the east side is greater, and the Grey Marls are there, on the south-east side, as seen at the surface, opposed to the Amuri limestone on the north-west side of the fault; and here also the Post-miocene conglomerates appear involved along the line of fault.

Between the Kekerangu River and the Clarence, below the Sawtooth Gorge, there are two or three lines along which the Post-miocene conglomerates are involved between older rocks on both sides of the principal fault-line.

Between the Lower Clarence and the eastern base of Mount Fyffe, west of Kaikoura Peninsula, the fault-line is single, and is shown by the manner in which the Cretaceous and Cretaceo-tertiary rocks have been thrown down and pushed under the old Secondary and Palæozoic rocks of the higher part of the Looker-on Mountains.

From Mount Fyffe to the Upper Conway, along the base of the south-west continuation of the Looker-on Mountains, the line of fault can be clearly traced; but at Green Hills, and in the Upper Charwell, it is again as a double line, separated by a distance of about a mile one from the other. The western line, along the foot of the range, has old rocks on both sides of the fracture; and there are here no Post-miocene conglomerates involved along the line of fault. But the more recent displacements have taken place along this line, and the effects of these are yet clearly traceable at the surface along the line of fault. More to the east there is a considerable development of the Amuri and Cretaceo-tertiary series, closed by the Amuri limestone, the higher beds having been removed by denudation prior to the first displacements along the fault-lines. Some 40ft. of Post-miocene conglomerates overlies the Amuri limestone; and, as seen in Limestone Creek, this is in contact with the old rocks on the western side of the fault-line, and both this and the Amuri limestone, dipping at a high angle, appear as though they passed under the old rocks on the western side of the fault.

From the Conway to the source of the main branch of Lottery Creek, and thence into the upper part of the valley of the west branch of the same creek, the fault-line has not been closely examined; but, viewed from a distance, the dislocation is clearly traceable by the depression or drop of the eastern side along the line. And that this also is the line along which the earlier displacements took place is shown by the fact that it now limits the western and northern extension of the Tertiary and volcanic rocks of the district. The upper part of the main branch of Lottery Creek runs along the fault-line for some distance, as also does it (the fault) along part of the upper valley of the west branch of the creek; but at the point where this branch of Lottery Creek turns sharp to the south-east and east, the line of fracture is continued west into the valley of the Hanmer River. It is not clearly traceable at the surface, west along the southern side of the Hanmer Plain, on account of its being for that distance nearly coincident with the beds of the lower Hanmer and Percival Rivers, and of the Waiau-ua between the upper end of the Waiau Gorge and the western end of the plain.

The fault-line and earthquake-rents, new and old, are again clearly traceable from the western end of the Hanmer Plain, along the Waiau-ua and Hope valleys, to the junction of Kiwi Creek with the Hope River, and, without doubt, extend to and across the main range into the watershed of the Teremakau River; but no examinations have been made with a view of tracing and proving the existence of this line of fracture on the western side of the water-parting. But it may be noted that the upper and middle parts of the main valley of the Teremakau seem to coincide with the trend of the fault-line, which should run out on the west coast a little to the south of Hokitika.

From Kekerangu to the saddle leading from Lottery Creek into the valley of the Hanmer there is abundant evidence of great vertical displacement along this line. This, along the base of the Looker-on Mountains, must be measured by thousands of feet; and in all probability it exceeds the present height of the Looker-on Mountains, with the average thickness of the Lower Greensand and Cretaceo-tertiary formations added, and may therefore be estimated at from 10,000ft. to 13,000ft. Within the watershed of the Waiau-ua great vertical displacement is not so evident, but, for all that, the displacement may be as great. There are, however, no Tertiary or young Secondary rocks involved along this part of the line, and the rocks on both sides of the line of fracture are very similar in their lithological characters and in the degree of induration they have attained to. Hence it is that not even an approximation of the amount of vertical displacement can be arrived at. Liassic, Triassic, and Carboniferous rocks are present, and oppose each the same formation on the opposite side of the fault-line; and this fact might lead to the inference that no great amount of vertical displacement has taken place. But it must be remembered that for the most part the strata are inclined at high angles, and that thus placed, a formation of great thickness would require to be shifted vertically a distance equal to if not greatly more than its total thickness, in order that the direct evidence of this amount of shifting might be made to appear at the surface.

The Hanmer Plain, and those parts of the valleys of the Waiau-ua and Hope Rivers under consideration, may indeed to a large extent be valleys of erosion, but the fact is, and it is even more apparent, that they have been greatly influenced, if not determined in the first instance, by the existence of this fault-line.

As this line of fracture is crossed by others having a more north-and-south trend, further and closer examinations will have to be made in order to determine if the downthrow is always on the same side of the line, as it is quite possible that the lesser height of the mountains between the sources of the Hurunui and the Cannibal Gorge may be due to the downthrow of the strata being on the north side of the line of fracture; and this, it will be shown, is probable, when dealing with other lines of fracture that intersect this part of the district.

From the point where it touches on the coast-line near the mouth of the Flags River, this line of fracture may be considered as extending across the eastern part of Cook Strait, and in the North Island as being coincident with the line of fracture and earthquake-rents running along the western side of the lower Wairarapa Plain. This, within historical times, has been in movement also, and from Featherston to the sea on the west side of Palliser Bay the evidences of these latest movements can yet be traced. There can be no question but that prior movements have taken place along the same line, and that effects along this and other lines intersecting the southern part of the North Island must have altered the physical features of that district.

Fault No. 2.

This, which has been appropriately called the "Great Clarence Fault," is traceable by movements of modern date, and by a line of depression along the surface of the ground from the gorge of the Flaxbourne to the junction of the Gore with the Clarence River, a distance of about fifty miles. Between the Gore River and the north-east end of the Leslie Hills the country has not been examined, nor the line of fault traced. The Leslie Hills, however, are formed of a double range of hills with a depression between the two ranges. This depression lies along the line of fault and parallel with its direction from where last seen in the Clarence valley. Lying in this depression is an outlier of the older Tertiary rocks of the district, and these are involved, as seen in the Waiau Gorge, much in the same manner as are the

Cretaceo-tertiary rocks and Post-miocene conglomerates along the south-east slopes of the Inland Kaikouras.

The same line continued to the south-west skirts the western border of the Hurunui-Waiau Plain, and suggests the possibility of being concerned in the formation of the depression there existing. From the Upper Waipara it passes into the Ashley watershed west of Mount Grey and Mount Thomas ranges, and seems also to have been concerned in the formation of the remarkable depression known as Lee's Valley, which is linear with the direction of the fault-line, and separated from the Upper Waipara basin by a comparatively low saddle. Cretaceo-tertiary rocks are suddenly terminated along the supposed continuation of this line between the Hurunui and Upper Waipara Rivers. So far there are no Tertiary rocks known to exist in the Middle Ashley or along Lee's Valley.

It may appear a mere speculative dealing with apparent coincidences to attempt to recognise the presence and effects of this line of fracture further to the south-west than it has already here been traced; but the proofs of disturbances of the strata along the line are so evident, and the presumed modification of the features of the country so remarkable, that it seems difficult to avoid the conclusion that the fracture is actually continued to the south-west extremity of the Island; and, although everywhere the evidences may not lie rigidly along a direct line, this in itself is not important as evidence against or disproving the truth of the theory that the line does traverse the whole length of the South Island.

Crossing the Waimakariri valley at or near the junction of the Esk River, the line of fault passes the western slopes of Mount Torlesse, and intersects the Trelissick Basin, filled with Cretaceo-tertiary and Tertiary rocks, and, passing Lake Lyndon, reaches the low grounds of the Rakaia valley between the Lower Acheron and Lake Coleridge. On the south-west side of the Rakaia valley it passes Redcliffe, where Cretaceo-tertiary and Tertiary rocks are present on or close to the line; and in passing it may be noted that the coal-deposits of Big Ben and the Lower Acheron probably owe their protection, and preservation to the present time, to movements that have taken place in connection with the formation of this Great Fault line.

Again, by way of Redcliffe a depression leads into the upper valley of the north branch of the Ashburton River, where involved Tertiary rocks are said to be present, as certainly such are present in the valley of the Smythe River, by which the line reaches the depression in part occupied by, and surrounding, Lake Heron. In the Lake Heron district, and in the Upper Ashburton (main or south branch), fracture has taken place along two or more lines parallel to and not greatly distant from each other. This is shown by the presence of younger and fossiliferous rocks faulted against or involved between the old Secondary or Palæozoic rocks on both sides of the Lake Heron and Upper Ashburton Plains.

The presence and mode of occurrence of the younger rocks along the Smythe River and near Clent Hills Station, on the east side of the plains, and of the coal-rocks involved among the older rocks on the banks of the Cameron and along the Upper Potts Rivers, show this conclusively.

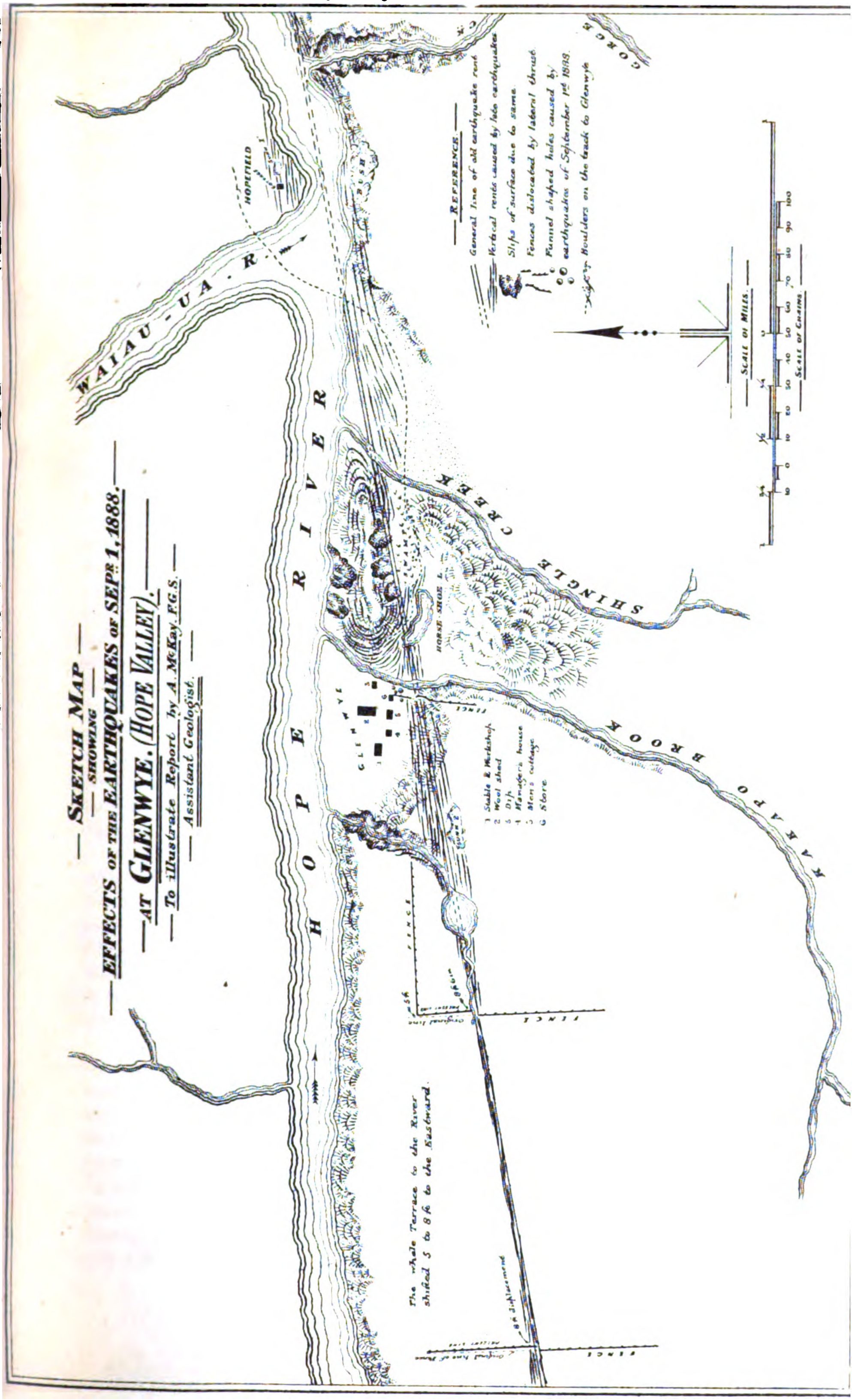
Passing Lakes Trip and Acland, on the south-west side of the Upper Ashburton Plains, a depression in the range on this side leads into the Rangitata valley, which the line again leaves by way of Forest Creek, the valley of which is coincident with the line of fault, and which, in a remarkable manner, divides the northern part of the Two-thumb Range from the ranges bounding the Mackenzie country on the east side. By the saddle at the source of Forest Creek the line of fault enters the Mackenzie country and the watershed of the Waitaki River.

That the low grounds of the Mackenzie country have originated during comparatively modern times may be shown in several ways; but that the basin of the Upper Waitaki watershed has been scooped out of a mountain-region by the action of glacier-ice, as is the popular interpretation of Von Haast's writings on the subject, is most unlikely, and no facts need here be put forward in disproof of such a theory. The area in question is in most respects perfectly analogous to, but larger than, the similar areas which have already been mentioned as found to the south-east or to the north-west of this line of fault so far as yet described.

The Upper Ashburton and Lake Heron Plains, the Trelissick Basin, Lee's Valley, and the Upper Waipara and Hurunui-Waiau basins differ principally in this: that they do not abut directly against the flanks of the main range itself, and are of considerably less extent.

The manner in which, due to its direction, the Great Clarence Fault and its continuance to the south-west gradually approaches the water-parting and main range of the island explains the chief and most important difference. That of greater size is only a question of relativity, and is but proportionate to the greater height of the mountains that back to the north-west side the Mackenzie-country Plains.

The action of glaciers and of glacier-rivers has effaced all traces of earthquake-rents that might be looked for at the surface over the whole of the Upper Waitaki basin; but, prolonging the line in its average direction, as determined further north in carrying this along the greater length of the Mackenzie country, it must appear as not a little remarkable that it passes close to the lower ends of the three larger of the existing lakes with such close correspondence that it is difficult to suppose that this is the outcome of simple chance. Chance or simple coincidence is not in the case, and each


Sketch Map
showing
Effects of the Earthquakes of Sept. 1, 1888.
at Glenwye. (Hope Valley).
To illustrate Report by A. McKay, F.G.S.
Assistant Geologist.
Reference.
General line of old earthquake rent
Vertical rents caused by late earthquake
Slips of surface due to same
Fences dislocated by lateral thrust
Funnel shaped holes caused by earthquakes of September 1st 1888
Boulders on the track to Glenwye
Scale of Miles
Scale of Chains
Waiau-ua R.
Hope River
Shingle Creek
Kakapo Brook
Gorge Ck.
Hopefield
Bush
Glenwye
Horse Shoe L.
1 Stable & Workshop
2 Wool shed
3 Dip
4 Manager's house
5 Men's cottage
6 Store
Fence
The whole Terrace to the River shifted 5 to 8 ft to the Eastward.

particular feature must be due to a cause or causes evident or obscure (due to action of a different kind), as the case may be. Glacier-ice may have modified to a considerable extent Lakes Tekapo, Pukaki, and Ohau, but indicative of their origin is the fact that this great earth-fissure intersects or passes close to the lower end of each of them; and this supposition is strengthened by the fact that in following further the line of fracture to the south-west it passes close to the lower ends of Lakes Hawea and Wanaka, which also, it may be assumed, in part owe their origin to the existence and near presence of the line of fault.

There is evidence showing, on the right bank of the Clutha, and along the valley of the Cardrona River, that the line of fracture is there present. Stratified deposits of clay, sand, and gravel belonging to the older deposits (not marine) filling the old lake-basins of Central Otago are there on the banks of the Clutha seen dipping at high angles, and along the Cardrona valley are found vertical, at elevations of about, or scarcely more than, 1,000ft. above the sea; while on Mount Criffel, a few miles to the south, beds of the same age have an elevation of 4,000ft.: proving conclusively that between the two localities the strata have been dislocated, the vertical drop being here on the north-west side of the fault. It requires no stretch of the imagination to connect this with the south-west extension of the Great Clarence Fault, which it has been shown probably affects the whole length of the Canterbury Provincial District, from the Hurunui River to the south-west corner of the Mackenzie country.

Five of the great lakes lying along the south-east base of the Southern Alps, strangely enough, lie just immediately to the north-west of the fault-line, and to these must be added Lake Heron and Lake Coleridge, within the Rakaia watershed.

Continued to the south-west, the line we have so far followed passes Queenstown at the eastern end of the transverse east-and-west reach of Lake Wakatipu. Along the line lies the deepest part of Lake Wakatipu, reaching to 370ft. below sea-level; and in this connection also it must be noted that Queenstown experiences a greater number of earthquake-shocks than any of the other townships of Central Otago—not even Pembroke excepted, which also lies not distant from the line of fracture.

The middle reach of Lake Wakatipu is, besides this, intersected by another great fault; and to this fact is in all probability due the great depth of this part of the lake, and also the prevalence of earthquake-shocks in this region. In describing this other line of fault reference will have to be made to other peculiarities of the physical features of the district surrounding Lake Wakatipu. Meanwhile, following the line of the Great Clarence Fault, this passes the lower end of Lake Mavora, an expansion of the Mararoa River, falling into Lake Te Anau. Further on the line of fracture runs along the north-west base of the Timutaka Range, and crosses the Waiau River, leaving Lakes Te Anau and Manipori to the north-west. Between the Waiau River and where the fault runs out to sea, close to the south headland of Preservation Inlet, a great dislocation of the strata has been known since the early days of the Geological Survey of Otago, and this is shown on the earliest Geological Map of Otago, by Sir James Hector, dated 1864. At that time it was not in the least suspected that this was but a part of a great fracture running the entire length of the South Island, and affecting a large part of the North Island as well.

From what has been stated above it will not be doubted that the Great Clarence Fault extends across Cook Strait, and makes itself evident on the northern shore in the vicinity of the City of Wellington. A number of lines converge and cross each other in the close vicinity of the city, and here it is somewhat difficult to distinguish one from the other. The line under consideration crosses the Rimutaka Range at the saddle by which the main road from the Hutt valley reaches Featherston and the Wairarapa Valley. This part of the line was affected by fresh dislocations during the earthquake-periods of 1848 and 1855. Further to the north-east it is not traceable within the Ruamahanga watershed; but within that of the Upper Manawatu it crosses the Tiraumea at the junction of its two main-source branches, and runs along the western slopes of the Puketoi Range to the north-eastern sources of the Manawatu. This part of the line has not been explored, and therefore it cannot be said what at the surface are the evidences of recent or of former movements along this part.

The same line continued into the Tukituki watershed affords abundant testimony of the activity of the causes operating; and from the neighbourhood of Waipukurau to the coast at or near Cape Kidnappers, the line, if continued direct, would take this course. But it is more probable that it follows the valley of the Tukituki River to the shores of Hawke's Bay inside Cape Kidnappers, and finally passes out to sea at the narrow and low isthmus separating Mahia Peninsula from the mainland north of Hawke's Bay. The great importance of this line as likely to affect the outlines and physical contours of the districts through which it passes need not in this place be adverted to.

Fault No. 3 (the Awatere Fault).

This is so called on account of the disturbances which affected part of the line along the Awatere valley during the earthquake years of 1848 and 1855.

It has been popularly supposed that the earthquakes of the years mentioned initiated the rupture which is traceable by surface-indications for the whole length of the Awatere valley; but I have already shown that this was a line of weakness long before the historical period, or the settlement of the country by a European population. Between the mouth of the Awatere and the east side of Taylor's Pass the line has not been closely examined. At the latter place, to the west of the road-line, the depression is very marked, and a small lake has been formed.

At the junction of Blairich Creek the effects of the last and previous disturbances are equally apparent; and the same may be said of any point along the line till reaching Molesworth Station, near the source of the river. Near Upcot and Gladstone Stations there are two lines of fracture, parallel to and about a mile distant from each other. In the upper valley the line is again single. This Awatere line is continued south-west into the Clarence and Waiau-ua watersheds, and crosses the latter river at or near Glenwye, the scene of the most violent disturbances during the earthquakes of September, 1888. As far as the Upper Waiau-ua this line is traceable, but in the Hope valley it is not so apparent. This may be owing to the intersection here of fault No. 1 with this No. 3, the Awatere line.

The extension of this, the Awatere line, further to the south-west is but a probability, and, for lack of definite information, the actual line of fracture cannot be traced or described in detail here. While this is so, a number of remarkable physical features and geological facts support the assumption that it does extend along the south-east base of the central ridge of the Southern Alps to and perhaps beyond the northern boundary of the Otago Provincial District. Its extension across Cook Strait into the southern district of Wellington is more decisively ascertained, and it is this line that forms the abrupt western shore of Wellington Harbour between Kaiwara and Petone, and, beyond Petone, follows the general direction of the Hutt valley. Beyond this it has not been traced.

Fault No. 4 (the Wairau Valley Fault).

That a fault runs along the Wairau valley from the Tophouse to the sea at the mouth of the river, on geological considerations, is most evident; and during the earthquake periods, when lines Nos. 2 and 3 were affected and reopened, fissures were also formed along the Wairau valley: but these cannot now be readily traced. This line, continued to the south-west, passes Lake Rotoiti and Lake Rotorua, and follows the general direction of the Buller River to the junction of the Inangahua, and reaches the coast midway between Westport and Greymouth. Continued to the north-east, it crosses Cook Strait and passes through the City of Wellington—three lines of earth-fractures thus converging on and intersecting each other within the boundaries of the capital of New Zealand.

These are the principal faults that affect the Marlborough and south-east district of Nelson, though, as not unimportant, might also be mentioned that which, near the Town of Picton, runs along the west side of Shakespeare Bay, and thence to the

Elevation, on the road from Picton to Blenheim. This deeply involves coal-bearing strata along part of the line, but it cannot be traced to the south beyond the Tuamarina valley, and to the north of Queen Charlotte Sound no attempt has been made to trace the line.

Outside the district specially dealt with in this report a number of great faults are known to exist in other parts of the South Island, as also there are one or two in the North Island. And, since it has been shown that the fractures and fault-lines that intersect the Marlborough and Amuri district of Nelson in their extension south-west and north-east must have greatly affected the physical features beyond these limits, I deem it right to show that not these four faults only have been a cause of such modification, but that others scarcely less in magnitude and importance have also exercised a powerful influence in depressing some parts and elevating other parts of the country. This is necessary, since issues of the questions raised have a wider application than what concerns only the north-east part of the South Island—the subject of the descriptive part of this report.

Fault No. 5 *(the Waimea Fault).*

This is traceable from the Town of Nelson along the western foot of the ranges to opposite Wakefield and Foxhill, and constitutes the first of three which in their south-west extension intersect near the lower end of the Inangahua valley, and there constitute a focus of depression in the same manner as the convergence of faults Nos. 2, 3, and 4 have produced the depression of the lower valley of the Hutt River, which, on the incursion of the sea, formed the harbour of Wellington, Port Nicholson. It may be merely a coincidence, but if this Waimea line be carried across the western end of Cook Strait and continued into the Hawke's Bay District it is found to be coincident with the line of disturbance along which lie the inverted young Tertiary strata of Kereru, inland of Napier. And between the Wairoa district of Hawke's Bay and Poverty Bay the continuation of this line forms the western boundary of the Secondary rocks that constitute the coast-line south-west and north-east of Mahia Peninsula.

Fault No. 6 *(the Motueka Fault).*

This runs along the eastern slope of the Mount Arthur Range, and is very evident where it crosses the Baton, Clark, and Skeat Rivers. Along this part of the line the Cretaceo-tertiary and coal-bearing strata of the district are deeply involved. The line follows the Wangapeka valley from the junction of the Dart with that river, and near the source of the Wangapeka coal-rocks are again deeply involved between the old rocks on each side of the fracture. This line continued to the south-west involves the coal-bearing strata along the Lyell Mountains and in the gorge of the Buller River below the junction of Lyell Creek, and intersects No. 5 in the lower part of the Inangahua Plain. From the Lower Inangahua the line runs along the eastern side of the Paparoa Range to the Grey valley near Brunnerton, and thus far there are several faults on or near the line of fracture, in which the coal-bearing strata are included. Between Greymouth and Clifton, at the mouth of the Wanganui River (south of Hokitika), the line runs out to sea, but at the south of the latter place the line of fracture gradually encroaches on the land, and near the Paringa River the coal-rocks and other members of the Cretaceo-tertiary series are involved, granites and schistose rocks being in contact on the opposite eastern side of the fault. South of Jackson's Bay the line for some distance runs along the belt of magnesian rocks along the Cascade River, and a little east of the upper end of the different sounds from Milford Sound to Thompson Sound, but across the sounds further south, and passes between the outer peninsular part and the main part of Resolution Island, between Breaksea and Dusky Sounds. In the South Island this is the line which has had to do with the depression of the west coast between Greymouth and the mouth of the Haast River, and more than any other may be taken to explain the exceedingly abrupt western slope of the Southern Alps of New Zealand. This matter has already been referred to (see *ante*, pp. 2, 3).

From the mouth of the Motueka River this line, carried across the western end of Cook Strait, enters the North Island a few miles south-east of the mouth of the Patea River, and crosses the Wanganui twelve miles below the point where the river changes its direction from a south-west to a south-east course, and, continued further, just touches on the western part of Lake Taupo. Crossing the Waikato a little below where the Waiotapu joins that river, the line passes through the middle of the hot-lake district, and terminates in White Island in the Bay of Plenty. How far this is an important line of fracture and volcanic disturbance in the North Island I need not pause to determine.

Fault No. 7 (the Takaka-Karamea Fault).

This is traceable along the whole length of the Takaka valley, and the Karamea above the Karamea Bend. Vast displacements and involvements of the coal-bearing strata have taken place along this and the other fault-lines of the western districts of Nelson. Continued to the south-south-west, this line intersects Nos. 5 and 6 near the lower end of the Inangahua Plain, and the line, theoretically prolonged, crosses the Southern Alps at the source of the north branch of the Rangitata River, and, passing through the whole length of the Mackenzie country, passes through the Oamarana Saddle into the Manuherikia watershed, where there is abundant evidence of faulting along the base of the Dunstan Mountains. The line crosses the Molyneux at the junction of the Manuherikia, and, passing the source of the Pomahaka River, enters the watershed of the Mataura River east of Switzer's Diggings, in the Lower Waikaka—where also the older quartzose drift-gravels are deeply involved by faulting—and, continued across the Southland Plains, passes Bluff Hill, and across Foveaux Strait into Stewart Island. In the southern part of Stewart Island this line, singularly enough, runs along the belt of tin-bearing country, which is a narrow belt of schistose rocks involved between granite developments to the east and west.

Fault No. 8 (the Lower Buller Fault).

This runs along the west coast between the Karamea Bight and Greymouth, and can be best studied between the mouth of the Mokihinui River and the Fox River, where it leaves the Paparoa Mountains. Between the Mokihinui and the Buller Rivers, the downthrow being on the west side of the line of fracture, the coal and coal-bearing strata are displaced nearly 2,000ft., and the sheer wall of the dislocation between the Ngakawau River and the entrance to the Buller Gorge is so evident that it forms the most remarkable physical and scenic feature of this part of the west coast. South of the Buller River the coal-rocks do not cap the mountains to the east of the line of fracture; and the proof of the continuance of the line lies in the fact that the coal and Tertiary rocks are limited to the west side of the theoretical continuation of the line of fracture, and on this side of the area are, north of the Buller, in a nearly horizontal position, but to the south dip at higher angles. The granite and other crystalline rocks of the mountains to the east appear also along the coast-line from Cape Foulwind to south of the Fox River, showing that here, as in the Kaikoura district, on the downthrow side of one fault, the downthrow is less as this is receded from till reaching the next parallel or sub-parallel fracture, and the country is relatively, and, on the whole, may be actually, elevated on the opposite or downthrow side of that fracture. It is this rolling motion of the fractured masses that has given rise to that inequality of the surface which the active agencies of denudation have carved and moulded into mountain and valley. This line, continued to the south-west, crosses to the eastern watershed of the Island, north of the source of the Hunter River near the north boundary of Otago, a point at which several other lines meet and intersect, there forming a focus of elevation; while, further to the south-west, in the Te Anau Lake district, by the union of these with another set of fractures there is a focus of depression.

Fault No. 9 *(the Te Anau-Hollyford Fault).*

This runs nearly north-and-south from Sandhill Point, on the west side of Tewaewae Bay, Foveaux Strait, to Cascade Point, on the west coast between Jackson's Bay and the mouth of the Hollyford River, and is one of the most evident faults of the whole series. On the western side of this is the great crystalline mass into which have been cut the many fiords that in various situations render picturesque, wildly romantic, or in the highest degree majestic the west coast of the Provincial District of Otago. Along the line of fracture, to the east of this tract of rugged and highly mountainous country, lie Manipori and Te Anau Lakes. The eastern shore of the latter is generally low and largely formed of Tertiary marine rocks; while Cretaceo-tertiary rocks are found further north, and nearer the head of the latter lake. The actual fault-line lies along the bed of Te Anau Lake throughout its whole length, a distance of forty miles. Over the intervening space, and along the upper and middle parts of the Hollyford valley, the evidences of this great line of fracture are not less clear, unaltered rocks of Triassic or Carboniferous age being involved between mica-schists to the east and granites to the west in the low grounds of the Hollyford valley. Above Lake McKerrow the line leaves the main valley and follows that of Pyke's Creek to the coast-line at or a little south of Cascade Point.

All geologists who have examined the country agree that an immense fault separates the crystalline rocks of the west of Otago from the mica-schists and unaltered or Tertiary rocks to the east of the line described. The only question that is likely to arise in this connection affects the period at which the fault itself began to be formed, or that at which the faulting action ceased and the present period of supposed rest may be said to have commenced. Triassic, Cretaceo-tertiary, Middle Tertiary, and younger Tertiary or Pleistocene rocks are all involved along one or other parts of the line, and it may therefore be that, whenever the rupture of the fundamental rocks did take place, the last and not the least important movements have been of comparatively recent date.

Fault No. 10 *(Moke Creek Fault).*

This, by the presence and deep involvement along it of Cretaceo-tertiary and Tertiary rocks, has been traced from the northern shore of the east-and-west reach of Lake Wakatipu to Stony Creek, on the Shotover. Continued southward it passes between Mount Nicholas and the main mass of the Eyre Mountains, and in this direction it has also included and preserved some beds of the same age as are met with at Bob's Cove, on the north shore of this part of Lake Wakatipu. The line of fracture in all probability reaches into the Oreti watershed, and passes the north-western end of the Five River Plain, and along the eastern base of the Takatimu

Mountains, to the sea near the Township of Orepuki. Near the middle of the east-and-west reach of Lake Wakatipu this line intersects the south-west extension of No. 2 (the Great Clarence) fault, and jointly the effects of the two have been the cause of the great local depression now filled by the waters of the lake. It might be difficult to arrive at a just conclusion as to what has in this direction been due to the presence of fault No. 2; but that No. 10, by the great vertical displacement of the strata on the east side of the fault-line, has had an effect in determining the position of greatest and abnormally great depth of the lake is very evident.

Unaltered rocks of Palæozoic age, Cretaceo-tertiary and Tertiary rocks, are involved along this line between the north shore of Lake Wakatipu and Moke and Moonlight Creeks. There are not now any rocks belonging to the Te Anau or Maitai series nearer than the western shore of the upper arm of the lake, and, as all the schistose strata of the Richardson Mountains dip at high angles to the west, the vertical displacement along the east side of the fault must have been very great, and the amount of denudation which has since taken place to remove all traces of the unaltered rocks over a distance of fifteen miles must also have been very great.

With respect to the Cretaceo-tertiary and Tertiary rocks included along the fault-line, these must have been wide-spread over Central Otago during Miocene times. These have been wholly removed, except where included and protected along fault-lines. The nearest Tertiary marine rocks are, to the west, thirty-five miles distant, and to the east fifty miles distant.

Fault No. 11 *(the Kyeburn Fault).*

This runs along the east side of the Maniototo Plain, Central Otago, from the Swinburn to the western base of Kyeburn Peak, and through Clark's Diggings, between Kyeburn Peak and the east end of Mount Ida Range. Along this line auriferous-quartz gravels are found at 1,300ft. along the bed of the Kyeburn, and at 4,000ft. five or six miles further to the north. To the north the rocks on both sides of the fracture have been elevated, and further south the rocks on the western side of the fault-line are relatively much more depressed than those to the eastward. This line can be traced as far to the north as the gorge of the Ahuriri, above where that river joins the Waitaki. To the south the line continued runs past Macrae's Diggings, along the Upper Stoneburn and Silver Peak Range, to Blueskin Bay and Otago Peninsula, involving Cretaceo-tertiary rock at various places along this part of the line.

Fault No. 12 *(Waihemo Fault).*

This fault runs along Shag valley and the south-west slopes of the Kakanui Mountains and the Horse Range, to the sea at the mouth of the Shag River. Along the lower part of Shag valley it has a measurable displacement. On the south-west side of the fracture the higher beds of the Cretaceo-tertiary series are in contact with the lowest beds forming the coal-bearing series of Shag Point. Towards the south-east there must be a displacement vertically of not less than 2,000ft. on this line, but the amount is considerably lessened as the line is followed up Shag valley.

Minor faults and fractures affecting strata of all ages are of frequent occurrence in all parts of the country, but of these it is not necessary that any notice should be taken. The twelve great lines of fracture described must have exercised such a modifying influence on the physical features of the South Island as to satisfy all that is here contended for. Along all these lines it has been shown that great vertical displacements have taken place, and wherever there are distinct proofs of such displacements there is also evidence that for the most part they have taken place since the close of the Miocene period.

Looking at the accompanying plan, on which these lines have been traced, and on which it is distinctly shown where the lines are known to have been affected within the historical period beginning with the settlement of the country, and on which, also, faultings of older date are clearly displayed, it will be noticed that at several points two or more of these lines intersect, and that these intersections take place in what may be called areas of depression. Notable among these is that surrounding the City of Wellington. Here, within a radius of five miles of the city, the Clarence, the Awatere, and Wairau faults converge on each other, and it cannot be doubted that Port Nicholson is of comparatively recent origin. It is true that a slight upheaval accompanied the last violent earthquakes, and beaches and boulder-banks around the shores of the harbour are now found 4ft. to 8ft. above high-water mark; but there is no direct evidence of the land having within a recent geological period stood at a lower level than that just indicated, while there are distinct evidences of a downward movement of the land east of Karori and Johnsonville to the extent of 500ft. The line of fracture runs along the north-west shore of the harbour from Petone to the city, and thence is traceable along the Tinakori hills for some distance to the south-west.

Fault-lines Nos. 5, 6, and 7 converge so as to intersect each other near the lower end of the Inangahua Plain, along the east side of which heavy faults involve deeply the coal-bearing strata of the district. The Inangahua Plain may not be wholly due to a local depression of this part of the Buller valley, but the disposition of the coal strata on both sides of the valley affords evidence supporting the supposition that it is.

In the Canterbury District the Mackenzie Plain is also a low-lying tract compared with the highly mountainous character of the surrounding parts, and it is worthy of note that here also different lines intersect each other. This also is the case at Lake Wakatipu, producing the great depression of the middle part of the lake. In like manner different lines cross each other in the vicinity of Te Anau Lake, also an area of depression.

Faults Nos. 1, 4, 5, 9, 10, and 11 intersect each other within a radius of fifty miles from a point some eighty miles west of Hokitika, and this, by the same reasoning, must also be regarded as an area of depression.

Mr. Edward Dobson, C.E., engineer of the Lyttelton and Christchurch Railway, in a report to the Secretary of Public Works for the Province of Canterbury, 1866, noted a peculiarity in the physical structure of the mountainous districts of the Province of Canterbury and of the South Island generally, by which it is made to appear that all the principal rivers of the south, east, and north coasts of the Island may have had their sources in an elevated tract of land now submerged, and which was situate west of Hokitika, within the area circumscribed by the intersections of the lines of probable extension of faults 1, 4, 5, 9, 10, and 11. I have not Mr. Dobson's report to refer to, and must content myself by making an extract from Sir Julius von Haast's writings on this subject. He says, "Mr. Dobson . . . points out a very interesting and suggestive fact which has not before been noticed —namely, that all the principal valleys from the Hurunui in the north to the Makaroa in the south radiate, as it were, from a common centre, situate about fifty miles to the north of Mount Darwin, or about forty miles west of Hokitika. This remarkable phenomenon is more than a coincidence, and it would not, therefore, be too rash to conclude that, during or shortly after the period when the rocks now forming the Southern Alps had been thrown into the huge foldings they now exhibit, some abyssological force of enormous power, situate near that point, had laid the foundation of the remarkable orographical feature by which the country appears starred. . . . Mr. Dobson at the same time observes, 'It might be imagined that these radiating lines would form passes through the central chain at the head of the valleys, but' (he thinks that) 'with the exception of the Hurunui valley this is not the case.' However, a closer examination of the map will show that such depressions in the Southern Alps do generally exist, although the line, when crossing the watershed, is sometimes a little deflected."—("Geology of Canterbury and Westland," pp. 175, 176.)

Neither Mr. Dobson nor Von Haast, as cited above, appears to have had the impression that land existed in the area to the west of Hokitika, to which reference has been made, and yet all the facts as stated in the quotation just made, or otherwise given in this report, point to the existence of land beyond the present limits of the west coast at the time when the peculiar feature described by Mr. Dobson was impressed on the contours of the South Island.

Von Haast thinks that the phenomenon of the radial direction of the river-valleys is more than a coincidence, and with this conclusion most will heartily agree; but if it be supposed—and it has been often asserted—that the Southern Alps of New Zealand as they now are are but the eastern side of a great anticlinal ridge the central and western parts of which have been removed by denudation or depressed below the level of the sea, there will be no difficulty in accounting for the remarkable phenomenon of the radial character of the valley-systems of the South Island, without calling on or inferring the action of "some abyssological force of enormous power," at least for that purpose. Von Haast, further on in the same work ("Geology of Canterbury and Westland"), says, "Looking at New Zealand as a whole, from a geological point of view, we observe that its principal characteristic feature consists of a high longitudinal chain, which runs from Windsor Point, the most westerly part of the South Island, to the East Cape, the most easterly point of the North Island. This great mountain-chain, broken through by Cook Strait, falls rather abruptly towards the west, having from the divide only a breadth of about eight to ten miles. Towards the east it slopes down more gradually, a breadth of fifty miles not being uncommon. This remarkable chain, of which the geological structure is generally uniform throughout, is only the eastern wing of a huge anticlinal arrangement, of which the western portion has either been destroyed or submerged below the Pacific Ocean."—("Geology of Canterbury and Westland," pp. 241, 242.)

It requires no great stretch of the imagination to realise the probability of the connection of the crystalline rocks of the north-west of Nelson with those of western Otago; and it may be noted that a line drawn from Rocks Point, in the Collingwood district, to the entrance to Milford Sound intersects the focus of the radial lines of the Canterbury and Otago river-valleys, and the seat of the supposed "abyssological force" which is thought to have been instrumental in their formation. If the Southern Alps form but the eastern side or part of the eastern wing of a great anticlinal arrangement, there can be no difficulty in supposing that the greatest height of land existed somewhere in the neighbourhood of where the river-valleys of the present east side of the mountains point to, and ordinary denudation alone would be sufficient to account for this phenomenon. I have already shown that where a number of the fault-lines traced on the map intersect each other, there we have an area of depression; and this area at sea forty miles or eighty miles west of Hokitika does not appear to be an exception to the rule. Moreover, from the greater number of lines there intersecting, it might be expected that the resulting depression would be all the greater; and this also appears to be the case. Further, to the landward side, and between the present coast-line and the crest of the Southern Alps, two or more lines of fracture have been traced, and these yet further should intensify the general lowering of this part of the west coast. The peculiarity of the river-valleys of the east coast therefore points to the existence of high land within the area indicated, and equally the existence of the fault-lines explains why and how this has disappeared. Such being the facts, we may safely conclude that great changes in the physical features of the country have taken place since the close of the Miocene period. In the Marlborough and Amuri district of the north-east part of the South Island the principal orographical features have arisen since then, and the evidence is as conclusive that the present physical features of the north-west district of Nelson are not of older date, and it seems reasonable to arrive at the same conclusion with respect to the whole of the northern part of the Island, north of the Rakaia and Hokitika Rivers. Over the whole of this region it is probable were deposited some of the members of the Lower Greensand and Cretaceo-tertiary formations, and widely over the same district were spread also rocks of the Tertiary period. Subsequently the lines of fracture were either initiated or again began to be active, with the result that on one side the land rose, while on the opposite, generally the south-east side, it was relatively depressed; and to this action, whether continuous or intermittent, we owe the existence to-day of the Looker-on Mountains, the Inland Kaikouras, and the mountains between the Awatere and Wairau valleys, and, I might add, the Southern Alps of New Zealand as they appear at the present time.

ON THE PROSPECTS OF COAL WITHIN THE MANGAHAO BLOCK, PAHIATUA COUNTY.

REPORT BY ALEXANDER McKAY, F.G.S., ASSISTANT GEOLOGIST.

Wellington, 5th July, 1890.

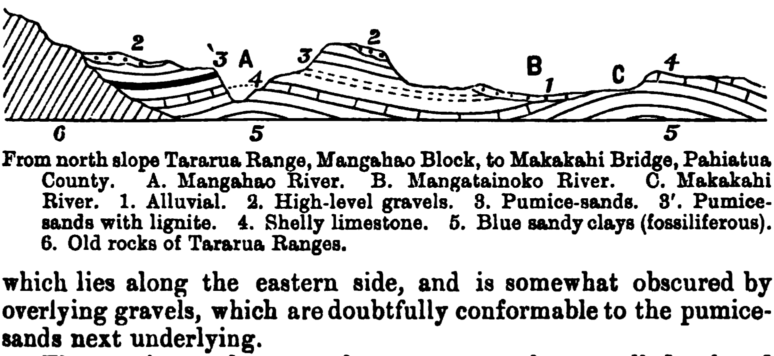
As directed, on the 30th June I went to Pahiatua, and the following day to the coal reserve on the Mangahao Block; and next day, the 2nd instant, I examined at various places the indications of coal to be seen within and in the neighbourhood of the coal reserve. On the 3rd I returned to Pahiatua, and on the 4th to Wellington.

REPORT.

The basin of the Manawatu above the gorge of the river, and east of the Ruahine and Tararua Ranges, is filled by young Tertiary rocks, which to the eastward rest on Lower Miocene and Cretaceo-tertiary strata, and to the south and west on old Secondary and Palæozoic rocks. In the southern part of the basin drained by the Tiraumea, Makakahi, Mangatainoko, and Mangahao Rivers, brown sands, passing upwards into blue sandy clays, form the lowest of the younger series of rocks. These are well seen along the road and railway-line from the southern limit of the basin to and in the neighbourhood of Eketahuna, and thence along the main road to Pahiatua and Woodville. At the Makakahi bridge, four miles and a half south of Pahiatua, these beds are overlain by shelly limestone, forming hilly country to the east of the road-line. Further north, and directly east of Pahiatua, these calcareous beds no longer appear at the surface, and the lower hills of smooth outline in this direction are evidently of the next succeeding series, which is composed mainly of sandy beds, beds of pumice-sand and sandy clay. These appear along the banks of the Mangatainoko, further in the direction of Woodville.

From the Makakahi bridge along the road leading west to the Mangatainoko nothing shows but the alluvial deposits of the low grounds generally; but on the way to the Mangahao Block and coal reserve, between the Mangatainoko and Mangahao Rivers, a ridge of hills exposes the sequence of rocks already described, and these are well seen in the cutting of the road before reaching the Mangahao River.

The general arrangement of the beds present in these hills, as shown in the following section, is as a syncline, the trough of



From north slope Tararua Range, Mangahao Block, to Makakahi Bridge, Pahiatua County. A. Mangahao River. B. Mangatainoko River. C. Makakahi River. 1. Alluvial. 2. High-level gravels. 3. Pumice-sands. 3′. Pumice-sands with lignite. 4. Shelly limestone. 5. Blue sandy clays (fossiliferous). 6. Old rocks of Tararua Ranges.

which lies along the eastern side, and is somewhat obscured by overlying gravels, which are doubtfully conformable to the pumice-sands next underlying.

The pumice-sands, as such, are not nearly so well developed here as they are on the west side of the Mangahao River, the bulk of the beds occupying the same horizon being grey sands.

About two-thirds down the western side of the range shelly limestones, striking S.W. and dipping to the S.E., appear under the lower beds of the pumice-sand series, and are underlain by blue sandy clays (fossiliferous), that pass downwards into more sandy beds of the same colour, which along the foot of the range extend to the Mangahao, and form high cliffs on both banks of the river.

After crossing the Mangahao River the road leads along the left bank some three miles, showing here and there sandy beds under the gravels of the river-terraces. At the distance mentioned from the crossing, the road to the coal reserve is by a bush-track across the terraces and low hills on this side of the river.

In the principal creek draining from the hills to the west across the coal reserve to the Mangahao River, the section is sufficiently clear to show the position and relationship of the supposed coal-bearing strata. Less than a mile below the survey-camp on this creek the shelly limestone crops out dipping to the N.W., and is followed up the creek by a considerable thickness of blue and grey soft sandstone. The dip of these beds seldom exceeds 20°, and is often as low as 10° or 12°. As the higher beds of the series overlying the shelly limestones are reached, pumice-sands make their appearance, and at the place where the lignite crops out form beds up to 4ft. in thickness.

The lignite, as several thin seams, 3in. to 9in. in thickness, is directly associated with the pumice-sands, and the whole is, as in the ranges between the Mangahao and the Mangatainoko, followed by heavy beds of conglomerates, the material of which is usually well rounded, and evidences the action of a large lake or the sea.

I did not reach far enough to the west to ascertain whether or not the beds on this side of the Mangahao form a syncline. From the abundance and angular character of the boulders of old rock in the creek-bed it is probable that they do not—at least, the limestone and lower rocks are not likely to appear between the outcrop of the lignite and the range to the westward.

The lignite in itself is of no value whatever, and, were its quality greatly better than it is, the thinness of the seam or seams would render it unworkable with profit.

The position, also, is such that even a thicker and workable seam of good brown coal could not at the present time be developed and worked so as to pay.

The following is the analysis of a sample of the lignite obtained from the outcrop of the principal seam :—

Fixed carbon	10·20
Hydrocarbon	9·53
Water	20·23
Ash	60·04
	100·00

It will thus be seen that the substance analysed is not in any sense of the word a coal at all, but merely a carbonaceous clay.

ON THE PROSPECT OF FINDING COAL ON THE NEW ZEALAND AGRICULTURAL COMPANY'S ESTATE, WAIMEA PLAINS, SOUTHLAND.

Report by Alexander McKay, F.G.S., Assistant Geologist.

Wellington, 15th June, 1890.

I have the honour to report that, as directed on the 2nd instant, I went to Riversdale, and the following day examined the site of the borehole four miles west of Waimea Station, and at the same time such natural exposures of rock as could be seen in the vicinity of the bore; and on the 4th and 6th I examined different parts of the estate, with the view of determining what the true coal-bearing sequence is, and the nature and position of the rocks passed through in the lower part of the borehole at the Wash.

Report.

The correspondence and previous papers attached to the instructions forwarded to me show that advice was sought with reference to the probable occurrence of coal when the borehole had passed through the calcareous sandstone forming the Waimea limestone, and had been sunk for some distance into the underlying rocks. The samples of rock-drillings forwarded were of such character as indicated the probable existence of coal similar to that found on the opposite side of the Hokanui Hills, at the base of the Forest Hill Range, and this at no great depth below the level then reached in the bore—some 200ft. Accordingly, the Director of the Geological Survey advised the continuance of the work.

At a depth of 129ft. 2in. from the surface the bore passed through the lowest member of the Waimea or Forest Hill limestone, and entered upon the argillaceous and arenaceous strata that underlie, and at "190ft. 9in. from the surface 8ft. of greensandstone, with shells, was passed through."* Below this it might have been anticipated that a variable but not very great thickness of quartz-sands and fireclay would have to be passed through before reaching the coal-seams that were reasonably expected to occur; but on the bore being sunk to a greater depth this change in the character of the strata passed through did not take place, grey and green sandstone, with some bands of non-bituminous shale, continuing to a further depth of 95ft., the total depth of the bore being now 285ft. 11in. The rocks at this depth not indicating the immediate cover of the coal, at this stage it would have been well if a survey of the district had been obtained, since this would have determined the nature of the rocks to be passed between the

* There is a possible mistake as to the presence of shells in this greensand, also as to whether it forms part of the lignite-bearing series.

calcareous sandstone and the coal itself, if present. Unfortunately, the bore was continued (without the samples being referred to the Geological Survey Department) a further depth of 235ft. 11in., through dark-grey and red shales or mudstones, varied only by a band of "pink crystallized limestone," 13ft. 6in., and some thin beds of ironstone and sandstone. Having reached a total depth of 521ft. 10in., work was suspended until further advice as to what results at greater depth might be looked for.

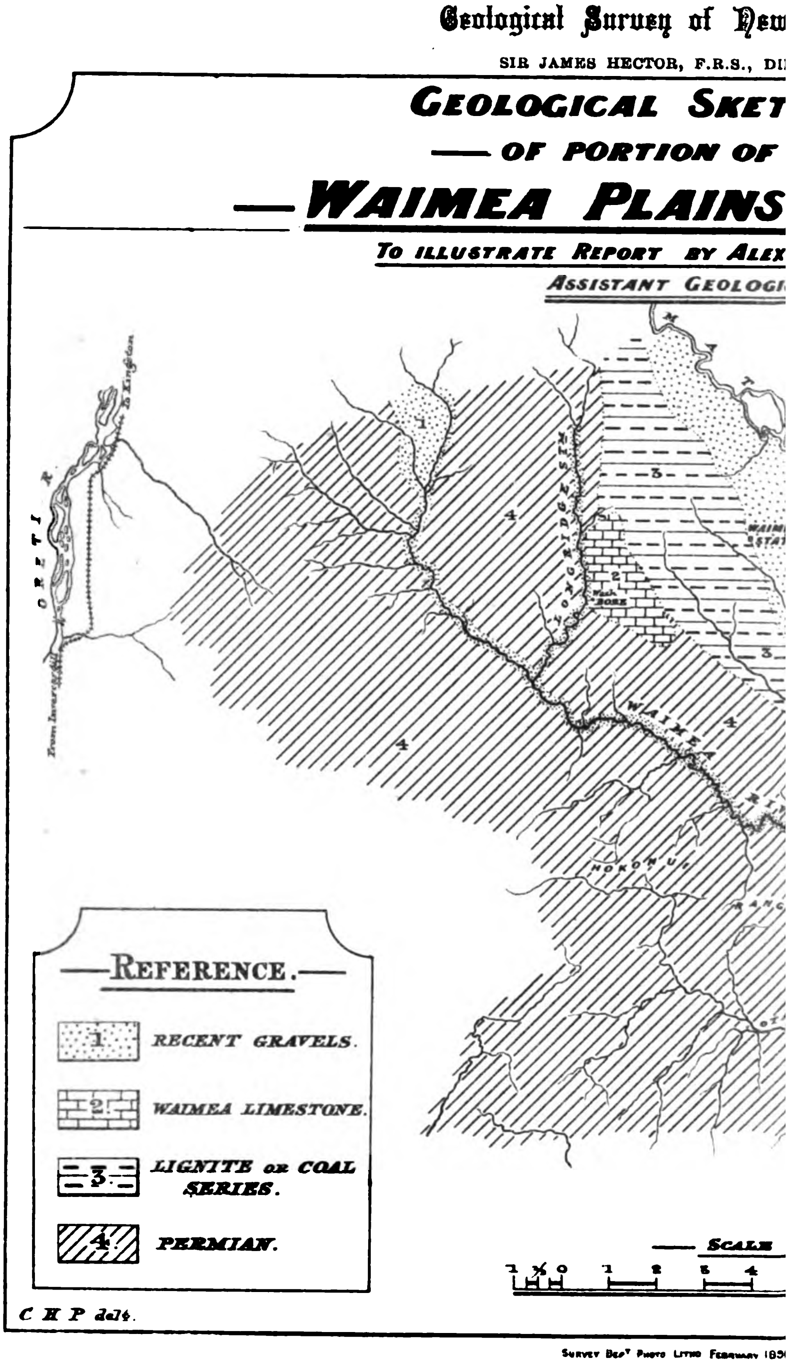
Within a mile of the borehole itself the only rock to be seen at the surface is the uppermost beds of the Waimea limestone, forming a cliff, where quarried, 20ft. in height, and sloping to the level of Longridge Stream, a vertical distance of 20ft. to 25ft., giving a total thickness above the general level of the low grounds of not more than 45ft.

The bore indicates nearly 113ft. as the total thickness of the calcareous rocks, and, as the beds are nearly horizontal—apart from the fact that surface-gravels obscure all the underlying beds—the beds under the limestone could not be expected to show for some distance east or west of the borehole, and, as a matter of fact, it is two miles and a half in either direction to the nearest exposures of rock that may be inferred to underlie the calcareous rocks at the Wash. There are, therefore, near the site of the prospecting borehole no indication of what rocks might be expected after having passed through the calcareous sandstones.

Two miles and a half to the eastward, and but a few hundred yards west of Waimea Home Station, a thick bed of lignite outcrops along the edges of the terraces on each side of the upper part of McKellar's Creek. This lignite has been worked for local supply for many years past. Being near the surface, and not being a first-class fuel, it was supposed that at a greater depth a superior coal might be found, and the hope of this seems to have led to the prospecting-works at the Wash. There is no evidence directly connecting the rocks associated with the lignite at Waimea Station with the calcareous sandstone at the Wash, on Longridge Creek; yet, had a seam of coal been found in the borehole—say, 100ft. to 200ft. below the Waimea limestone—I suspect it must have proved the same as that exposed and already worked near Waimea Station, and therefore would not have satisfied anticipations regarding it.

The lignite near Waimea Station is underlain by dark sandy beds, and overlain by sandy micaceous shales, weathering white. At many parts of the outcrop the upper beds have been removed, and coarse river-gravels have taken their place, and rest directly on the coal.

At first sight it might be assumed that the lignite-beds find their proper place at the base of the gravel, and in connection therewith; but this is not the case, the true relationship being quite clear in some of the older workings that have been made.


Geological Survey of New
SIR JAMES HECTOR, F.R.S., DI
GEOLOGICAL SKET
OF PORTION OF
WAIMEA PLAINS
TO ILLUSTRATE REPORT BY ALEX
ASSISTANT GEOLOGI
ORETI R.
To Kingston
From Invercargill
WAIMEA R.
HOKONUI
REFERENCE.
1 RECENT GRAVELS.
2 WAIMEA LIMESTONE.
3 LIGNITE OR COAL SERIES.
4 PERMIAN.
SCALE
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SECTIONS OF ST…
PASSED THROUH IN BORINGS …
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To illustrate Report by Alexr M…
Assistant Geologi…

SCALE OF FEET.

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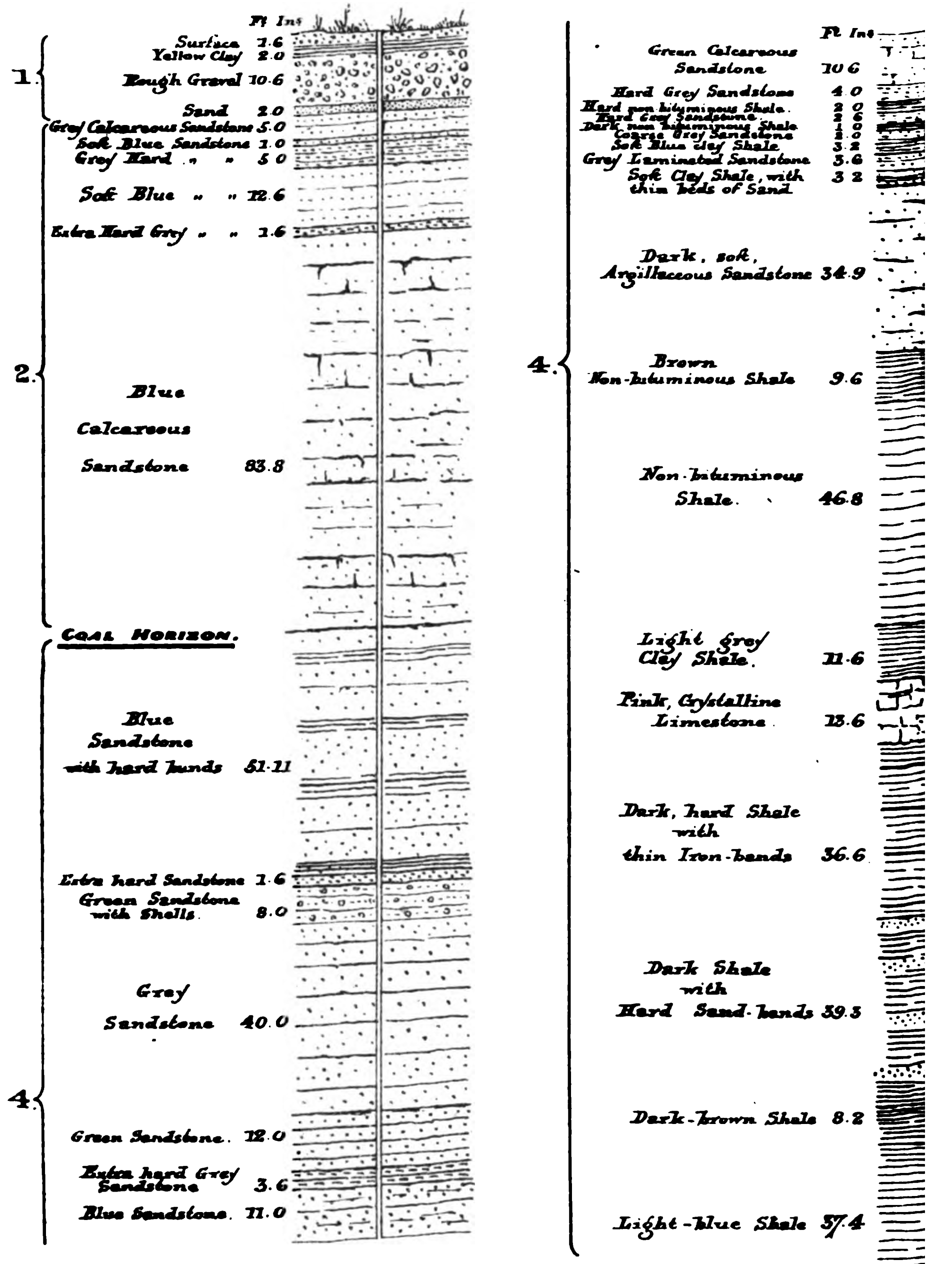


BORE AT THE WASH, NEAR LONGRIDGE STREAM.
Hokonui District.

Total L…
521.

Compiled from plans furnished by the N.Z. Agricultural Co.

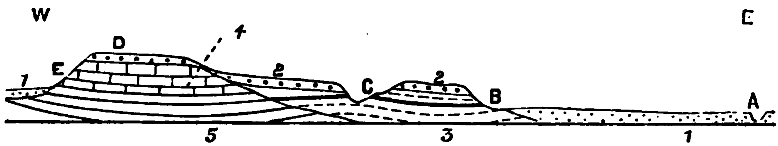
Survey Dept Photo Litho February 19…

In these the lignite and associated beds have a low or moderate dip to the eastward, and the lignite has been worked back from the edge of the terrace till the gravels directly overlying the outcrop give place to the true cover, on which the gravels rest, as on the lignite itself, unconformably.

On the opposite, or west, side of the gully the outcrop of the lignite is indicated by the number of springs and ranker vegetation about midway on the slope; but it has not been ascertained in what direction it dips. Apparently, the beds are nearly horizontal.

What the relation of the lignite-beds is to the calcareous sandstones at the Wash there are no means of exactly determining, excepting that the borings brought up from depths below the limestone gave no hint of the presence of the lignite-beds, and we must conclude either that the lignites are younger than the Waimea limestone, or that to the westward the limestone overlaps the lignite series, and rests direct on the old Secondary, or Permian, rocks that underlie and form the floor on which the younger deposits rest.

In illustration of the first supposition the following section —E.-W., from Mataura River to Wash, on Longridge Creek, Waimea Plain—is given:—

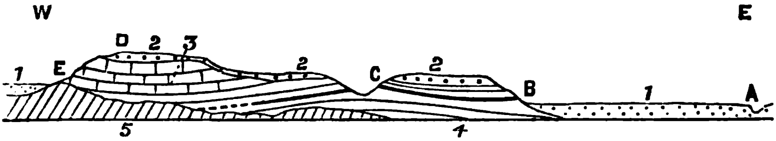


1. Recent gravels, at low levels. 2. High-level gravels. 3. Lignite series. 4. Waimea limestone. 5. Beds indicated by borings brought up from depths between 113ft. and 190ft. from the surface.

The dark-grey and red Permian shales that form the lower rocks, passed through in sinking the borehole, are supposed to lie below the datum-line of the section. The beds 5, underlying the Waimea limestone; beds 4, passed through in the borehole at D, do not correspond to any part of the lignite series as seen near Waimea Home Station, nor do they at all resemble the beds west and north-west of Mandeville which interpose between the limestones, and the sands and clays immediately overlying the coal- or lignite-beds.

The section from Mandeville west along the south bank of Otamita Stream, is incomplete, the limestones being absent from the upper part, and the coal or lignite beds are obscured in the lower part of the section. But the lower beds are not absent, as the lignite has been found, and partly opened out, on the flat on the opposite side of the stream, a few hundred yards above where the section of the coal-bearing strata ends on the south bank of the creek; and it is again seen about a mile further up the valley: so that there is little doubt the greenish and sulphurous sands of the section referred to would, if the section were complete and clearly exposed throughout, pass upwards so as to include the Waimea limestone, and downwards the section would also include the lignite-beds as the lowest, or basement, beds of the series.

From this it would appear that the beds 5 of the above section are unconformable to the limestone or calcareous greensands at the Wash, and it is equally clear that they form no part of the lignite series as developed near Waimea Station. But, on the other hand, the evidence favours the assumption that, although not proved present in the bore, the lignites find their proper place under the calcareous rocks of the Wash (Waimea limestone), and that the section is in this respect wrong, and should have been as follows:—



1. Recent gravels, at low levels. 2. High-level gravels. 3. Waimea limestone (calcareous sandstone). 4. Lignite series. 5. Permian.

In this section, west of McKellar's Creek, the lignites, with their accompanying sands and clays, are represented as underlying the Waimea limestone, and resting on the old rocks underlying. More to the west the lignite series thin out, and the limestones overlapping rest directly on the Permian rocks at and west of the borehole, D; and hence it was that no beds resembling those associated with the lignite, nor the lignite itself, were passed through in the bore.

However, the shaly character of the Permian rocks passed through in the middle and lower parts of the bore was such as reasonably led to the belief that the Cretaceo-tertiary coal-measures still lay underneath, and the occurrence of "greensandstone, with shells," might well fortify such a belief.

The record of the bore between 190ft. and 285ft. certainly reads very much as though beds below the calcareous members of the series, and overlying the coal, were being passed through, and it was only after a close study of the lower Permian beds, showing in the railway-cuttings between Stony Creek and Mandeville, and along the banks of Waimea Stream from Mandeville to the junction of Longridge Creek, that the truth of the matter became clear.

These lower Permian rocks strike N.W. and S.E. along the lower slopes of the Hokanui Hills, and the western part of the Waimea Plain, west of Riversdale, as red and dark-grey slaty shales in Round Hill, and form the western slope of the ridge and table-land to the north-west; and they show at many places between Round Hill and the junction of Longridge Creek.

The locality least distant from the bore at which these rocks were examined is opposite the junction of Cowan's Creek with the Waimea, and about two miles and a half from the Wash. Here the rocks are red and dark-grey shales, exactly corresponding with what was passed through in the lower part of the bore. The strike of these on the bank of the Waimea is N.–S., and the beds are nearly vertical. The north strike from the place indicated would carry the rocks to the Wash and borehole, and there cannot be a doubt that it is these beds that have been passed through in the lower part of the bore.

The accompanying plan shows the distribution of the rocks over this part of the Waimea Plain. On it I have not shown the younger gravels obscuring the Permian rocks along the Waimea River and the lower part of Longridge Creek. More to the east are the heavy gravels that overlie the lignite-beds, and the gravels forming the lower plain to the Mataura River.

As regards further prospecting for coal on the Waimea Estate, there is little hope that further work will result in the discovery of a coal superior in quality to the lignites that are already known and worked. The bore at the Wash was a reasonable and promising undertaking while its depth did not exceed 200ft., as thus far the presumption was strong that the beds passed through belonged to the coal-bearing series of Otago and Southland. But, coal not being found, and the character of the rocks continuing the same, this should have aroused doubts as to whether it was advisable to proceed until survey had been made.

ON THE OLD PHŒNIX MINE, TERAWHITI, WELLINGTON.

Report by Alexander McKay, F.G.S., Assistant Geologist.

Between the 4th and 7th of August I made a special examination of the various lodes and workings in the old Phœnix lease at Terawhiti, and have the honour to submit the following report on the same:—

Report.

The Phœnix lease, and the auriferous bands exposed in the different workings of the mine, are situate on the ridge of hills bounding the valley of Otorongo Stream on its south-east side, and of which the south-west part forms the water-parting between the drainage to the north-west and that which is discharged into Cook Strait by the Waireke Creek, on the south-east side of the ridge.

Wairekè Creek and the various small creeks feeding into Otorongo Stream yield alluvial gold, and the beds and banks of several of these were worked at the time gold was first discovered at Terawhiti. From these alluvial workings the stream of auriferous metal was traced to the rocks *in situ* on what is now the Phœnix lease. No true quartz reefs were found or have yet been found within or near the present lease, the gold occurring in bands of brecciated sandstone and slaty rock permeated by thin thread-like veins of quartz, and sometimes in such bands when even no free quartz appeared to be present. In every case, however, the auriferous bands consist mainly of angular material, chiefly sandstone; and where pure quartz is present this never exceeds (an estimated amount of) 20 per cent. of the whole.

The original Phœnix Company traced the gold of the various creeks to this source, and, after prospecting the outcrops showing along the crest of the ridge, put in a drive from the east side, cutting the principal auriferous band at a distance of 90 yards from where ground was broke at the entrance to the drive. The vein-stuff and walls of the lode here were found striking N.–S., and dipping W. at an angle of 50°. Drives to the north and south along the lode were made, and the stuff between the walls was prospected with the pan and by analysis, with varying results. The results obtained at this time were such as induced the shareholders to put in a low-level drive from the west side of the ridge, in such a position that this would cut the auriferous band at a level of 300ft. below the upper drive. This work was effected, and cut the gold-bearing deposit at a distance of a little over 600ft., and proved that the width of the auriferous band had increased to between 25ft. and 30ft. But, at the same time, as all tests since have shown, there is not in this lower level a corresponding increase in the percentage of gold present. On the contrary, the average to the ton is less than on stuff taken from the upper drive.

But so far were those interested satisfied with the prospects obtained that a small battery was erected, and a quantity of stuff from the upper level was put through the machine; which, however, did not yield as anticipated. Subsequently the upper drive was carried further, so as to pierce through the crest of the ridge, but without intersecting any thicker or richer bands of auriferous material. And, with the works very much as they now are, work was suspended and the company dissolved.

Within the past twelve months a fresh interest has been developed in connection with the possibilities of this mine, and, on the obtaining of a fresh lease by a new company, prospecting of the lodes at various points along the old drives and tunnels has been carried on. Samples obtained by pan-washing after roughly crushing the stuff were thought to be sufficiently encouraging, and, as the gold for the most part proved to be very fine, it was thought that the previous failure might have been due to the lack of sufficient precautions with respect to the saving and securing of the same. Samples were forwarded, and several tests were made in the Colonial Laboratory, which did not yield more than an average of 4dwt. or 5dwt. of gold to the ton. Subsequently a method of the chlorination process was tried, with results which, though on the whole pretty uniform, did not exceed an average of 6dwt. to the ton. And, finally, the samples taken by myself on the occasion of my late visit, here reported, gave results which, if more varied, are yet on the average not richer than former takings.

Of the samples last obtained, four were taken from the upper and four from the lower level. That from the northern extremity of the upper workings yielded at the rate of 13dwt. 6gr., and that from the end of the cross-drive 3dwt. 14gr., of gold to the ton of stuff. And traces of gold were obtained from a small leader crossing the main lode in the southern workings of the upper drive. The other sample is reported as being without gold. Of the four samples taken from the lower tunnel, that from the north end of the workings on the auriferous band gave 7dwt. 14gr. of gold to the ton; the samples taken from other parts of the lower workings giving only a trace of gold.

In the upper workings the auriferous bands are so narrow that, though richer in gold than the stuff from the lower drive, they are not likely to yield more profitably on being worked; and all round the average may be taken at from 3dwt. to 5dwt. to the ton.

The average thickness of the gold-bearing rock in the upper workings does not exceed 15in., and in the lower working, though this is supposed to be from 27ft. to 30ft., the sample from the western limit of the same not giving gold, and there being no clear wall on this side, the thickness must be considered as less than 27ft.

The main auriferous bands run north-and-south along the crest of the range between Cook Strait and the Phœnix Mine. North and north-east of the mine the range unites with and is indistinguishable from the mass of hilly country lying between the upper part of Otorongo Stream and Makara valley, and in this direction the auriferous bands run along the western slope draining into Otorongo Stream. Towards the south the auriferous bands should reach the shore of Cook Strait at the point where the range terminates in a high and almost vertical cliff, in the face of which the different strata are clearly exposed. It might be worth while prospecting this part of the coast-line for the same or similar bands of auriferous stone such as that found in the Phœnix Mine, or for quartz reefs carrying gold.

There can be no doubt but that the most of the alluvial gold obtained in the district has been derived from the southern part of the range, between the Phœnix Mine and the sea; and, although this has not been a great quantity, sufficient has been obtained to warrant the belief that workable reefs, or a workable deposit of brecciated and auriferous rock, such as is seen in the upper and lower workings of the Phœnix Mine, must exist somewhere.

The results last obtained, above noted, and tabulated below, are, however, not sufficiently good to warrant the statement that the deposits whence they were taken will, under the circumstances of the present time, pay for working. The mine-openings are difficult of access, and the prospects obtained do not warrant the construction of the necessary roads or the erection of expensive machinery for treatment of the ore. In the upper workings the gold-bearing bands are too thin, and in the lower too poor, to pay for working by the methods usually adopted in dealing with quartz reefs; and what remains to be done is to prospect for richer, if not more massive, deposits of the same kind. Below is the result of the analysis of the eight samples of stuff taken at the date of my last visit to the mine:—

Sample 1. Upper tunnel, main lode, north face of the cross-drive, 13dwt. 6gr. gold to the ton.
" 2. Lower tunnel, west side of auriferous band, no gold found.
" 3. Lower tunnel, east side of cross-drive to the south, no gold found.
" 4. Upper tunnel, south drive, from east-and-west leader, traces of gold.
" 5. Lower tunnel, east side of auriferous band, traces of gold.
" 6. Lower tunnel, end of the cross-drive to the north, 7dwt. 14gr. gold to the ton.
" 7. Upper tunnel, end of south drive, 3dwt. 14gr. of gold to the ton.
" 8. Upper tunnel, east-and-west leader in the south drive, traces of gold.

This is an average of about 4dwt. to the ton from the upper drive, and of barely 2dwt. from the lower workings. As all the samples were taken at haphazard, and without knowledge of the probable yield at the particular spot whence they were obtained, it may be that the like number of samples taken from other parts would give a different result; but, as this might be better or worse than the yield of the samples taken, the above must be considered as a fair average. Though, perhaps, somewhat less, the return from these eight samples is approximately the average of all the samples from this mine that have been tested in the Colonial Laboratory.

ON THE CRYSTALLINE LIMESTONES AND SO-CALLED MARBLE DEPOSITS OF THE PIKIKIRUNA MOUNTAINS, NELSON.

REPORT BY ALEXANDER MCKAY, F.G.S., ASSISTANT GEOLOGIST.

Wellington, 21st November, 1890.

INTRODUCTION.

ON the 12th instant Messrs. W. J. and R. R. Hunt made application for an examination of the marble deposits being opened out by them on the Pikikiruna Range, between the Motueka and Takaka valleys, of the Nelson District; and the same day I received instructions to proceed to the locality and make the examinations required. I left Wellington on the evening of the 12th November, and from the 15th to the 17th was engaged in making the examinations required, which led me to cross the Pikikiruna Mountains into the Takaka valley. On the 18th I returned to Nelson, and to Wellington on the 20th November.

Report.

The existence of deposits of crystallized limestone in the Riwaka district was first ascertained by Hochstetter in 1861, and the geology of the district has been since examined by the Director of the Geological Survey, by Mr. Cox, late Assistant Geologist, and by Mr. Park.

Mr. Park, in the last volume of Reports, gives a detailed description of the section across the Pikikiruna Mountains from Riwaka to Bates's, in the Takaka valley, and at page 229 of the Reports for 1888–89 gives a section showing the structure of the range, and the relation of the different strata and formations to each other. In this Mr. Park shows a narrow belt of limestone between the granite on the east flank of the mountains and the hornblende gneiss and quartzites that for the next four miles form the rocks on this side of the water-divide between the Motueka and Takaka valleys.

I did not have an opportunity of examining this limestone, as it is not shown in any of the cuttings along the new road across the range. Its presence on both sides of the Riwaka valley is well known, and on the southern side it has been quarried, and burned for lime. In the section illustrating Mr. Cox's report this limestone is not shown.

Following this limestone on the west side, and, as described by Mr. Park, following conformably are hornblendic syenites and quartzites, with subordinate beds of mica-schist, that form the eastern slopes of the range as far as, by the windings of the road, the six-mile peg. The rocks, as the section is read by Mr. Park, form a central anticlinal fold, on each side of which, between the anticline and the outcrop of the limestones, there is a syncline of the same rocks. Since the limestones showing along the eastern base of the mountains, and those commencing at the six-mile peg, conformably underlie the hornblendic syenites and quartzites, and, as exposed, seem to form the two sides of a syncline, it is a fair inference that they are, and therefore should be regarded as, belonging to one formation.

Mr. Park's section leaves no doubt as to this relationship. In that by Mr. Cox the limestone on the west side of the syncline is made to appear unconformable, and younger than the hornblendic and gneissic rocks; but in so far Mr. Cox's section misrepresents the actual relationship in this part of the section.

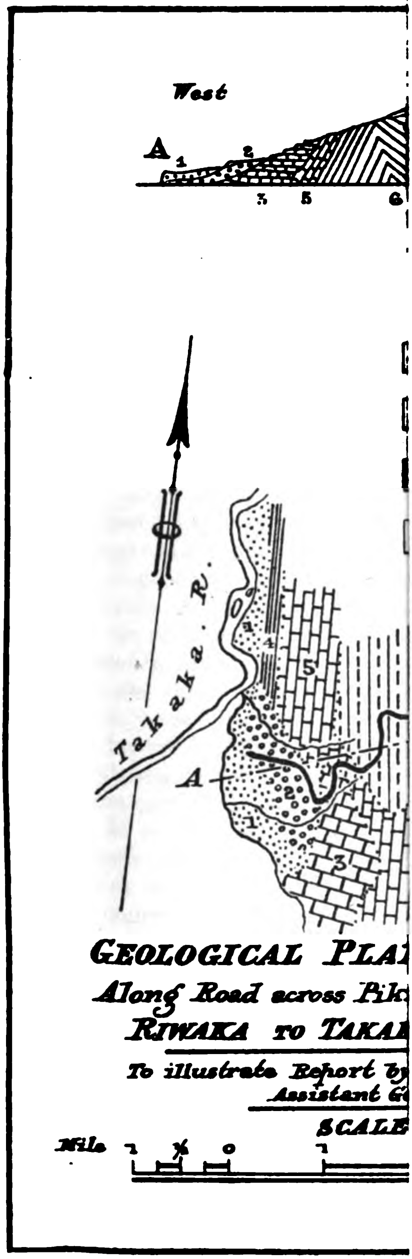
The structure of the country and the position of the limestones are well displayed along the new road from Riwaka to Takaka. The limestones outcropping at the six-mile peg dip at high angles to S.E., and here make their appearance from beneath mica-schist, the next rock to the east. For four or five chains west along the road the dip is at angles from 60° to 70°, and in this part the limestones are interbedded with one or two bands of mica-schist.

The highest band of limestone is of a greyish-blue, as described by Mr. Park. This gives place to a light-grey and coarsely crystalline limestone, veined or stained with iron-oxide. The demarcation of the veins in this stone is not abrupt, and thus, as a veined marble, its value is lessened. Beneath this the first rib of mica-schist appears, and beyond that there is again several chains of blue limestone. Where the road for a short distance turns more to the south-west, and more directly overlooks the valley of the north branch of the Riwaka, the limestone is again of a light-grey, or, in places, of a pure-white colour, and this development, followed a quarter of a mile to the north of the road-line, expands in thickness till the pure-white rock has an exposure of at least six or seven chains in width, and a little more to the north, in the sides of a deep ravine, is exposed to a depth of between 300ft. and 400ft.

From the road-line between the six- and seven-mile pegs a bold spur strikes south, and abruptly descends to the level of the north branch of the Riwaka River. Along the crest of this runs the belt of white marble, and on its eastern slopes are developed the two ribs, of blue, and the grey stone veined with red. This spur, besides being thickly covered with bush, is precipitous and broken, so as to render travelling difficult and tedious; and, time not admitting of its examination in detail, the smoother slope of the next spur to the east was selected for a descent into the Riwaka valley. The height at the saddle where the limestones appear, at the six-mile peg, is 1,600ft. above the sea, and, descending the spur to the east of the limestone ridge, the river-valley was reached where its level is a little under 400ft. above the sea, and here at this level the blue stone and the grey stone veined with red are at the foot of the eastern slope of the limestone spur. The clear-white stone I did not see, but was told that it is met with some short distance further up the gorge of the stream. Seeing this I considered of less consequence than an examination of the western side of the limestone belt and the descent of the range into the Takaka valley; and, having satisfied myself that the limestones on the east side of the belt dip at high angles under the hornblende-gneiss formation to the level of the Riwaka River, we retraced our steps to the six-mile peg and proceeded on the journey to the westward.

For the next three miles, or as far as the bridge across the north branch of the Riwaka, where on this side of the watershed the limestone ceases, the ground was too rapidly passed over to warrant any critical remarks on the reading of the section as given by Mr. Park. I noted the band of hornblendic gneiss mentioned by Mr. Park, and at various places observed that the dark-blue limestone is much contorted; and in this part of the limestone belt, although the colours are not in high contrast, pretty marbles might be obtained.

At the bridge the limestone ceases, and to the north-north-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west and north forms an abrupt scarp along the left bank of the stream. On the south side of the road the outcrop of the highest of the lower beds recedes to the east, and, till reaching the opposite side of the valley, is low and obscure; but on the outcrop returning to a south-west direction the lower beds appear as precipitous cliffs on the north and north-west sides of the range of hills through which the gorge of this branch of the Riwaka is cut. The limestones are also developed on the western slopes of the Pikikiruna Mountains and in the Takaka valley; but, except on the descent of the road to Bates's accommodation-house, near the junction of the Waituhi with the Takaka, I had not an opportunity of examining them.

On the eastern edge of the principal belt of limestone country, commencing at the six-mile peg from the foot of the road-cuttings in the Riwaka valley, there are two localities at which it is proposed to work the rock as a marble. The first lies in comparatively low ground in the valley of the north branch of the Riwaka, where, at 400ft. above sea-level, the marble may be opened out and quarried. The distance to where it can be shipped is six to seven miles, over a gentle, even grade, and a road has been formed to within a little more than a mile of the marble-outcrop. Grey and light-coloured marbles, suitable for architectural and monumental purposes, can be obtained here, and probably a little higher up the Riwaka the white variety, free from colour-veins, could be obtained at this or at a slightly greater elevation. The so-called white marbles are generally of a somewhat coarse texture; but the prospectors state that in this vicinity white stone of fine grain has been found.

No work has been done at this place with a view to proving the solidity and size of the blocks that might be obtained; and, in the absence of clear exposures of the rock *in situ*, it might be venturesome to express an opinion as to what the condition of the stone will prove when a quarry is opened out in each of the different varieties occurring here; but, judging from what I saw, I conclude there need be no apprehensions as to the size of the stone, which is likely to be equal to all ordinary requirements.

The second locality specially examined lies to the north of the road, a short distance west of the six-mile peg. The white crystalline stone at this place forms a hill isolated from those surrounding it, and which at its northern end is terminated by a precipice 70ft. to 100ft. in height, below which an exceedingly abrupt slope, formed of fallen blocks, descends to the bottom of the ravine which divides this hill from the continuation of the white stone further to the north. A quarry on the north-east or north end of this hill could be opened at a comparatively trifling cost, the chief expense being the construction of a road leading on to the Riwaka–Takaka Road at the six-mile peg.

As seen in the face of the cliff terminating the marble hill to the north, blocks of any size required, and removable by ordinary means, could be obtained; and, there being no doubt that the talus at the foot of the cliff buries it up to a great depth, there may be said to be an exposure at this place nearly 400ft. in height (this being the height from the top of the precipice to the bottom of the ravine, 1,150ft. above the sea). Exceptional facilities are thus afforded to open out and quarry the material.

From the six-mile peg the road to the eastern foot of the range is an excellent one, and is by a moderate continuous descending grade. The only objection that can be put as against the marble at this place is that the crystalline character of the stone is too pronounced, and the grain is rather coarse. For many purposes this may not be a serious defect, but it may be otherwise if it is intended to place this in the market as a statuary marble.

At the bridge over the north branch of the Riwaka River a formation of quartz rock and mica-schist makes its appearance. This strikes and dips conformably with the limestones overlying, and, so far as these circumstances determine, must be regarded as, with the limestone, forming one series, both being referable to the Lower Silurian period. Mr. Park considers the lower rocks as distinct, and refers them to the Cambrian period; but he gives no sufficient reasons why this should be done. The same rocks appear as schists in the core of the anticline in the section along the Baton River, but no one has ever regarded these as belonging to a dierent formation from the Silurian. With much better reason might the schists, hornblendic syenites, and quartzites overlying the limestones have been separated from the limestone and regarded as of Upper Silurian age. These, following the limestones of the Camelback, dip up the river, and their higher beds either pass under or abut against the fossiliferous Upper Silurian rocks of the Baton River section. There, most probably, they are correctly referred to the Lower Silurian formation, and they are the equivalents of the beds mapped by Park as Cambrian.

Between the bridge over the north branch of the Riwaka and the height of land at the saddle by which the road crosses the range into the Takaka valley the rocks are quartzites underlain by siliceous slates and mica-schists, dipping at moderate angles to E. or S.E. At places thin veins of clear-white quartz occur, striking in a north-west direction.

Between the saddle, 2,320ft., and the first big bend of the road on the west side of the range, dark-blue limestone shows along the roadside, but I had some doubts as to whether these rocks are actually *in situ*, it appearing as though they had slipped from the mountain overlooking the road on its south side. Either way, this is a matter of small consequence, and affects only the details of the section in this part. Between the first and second bend in the road there is a band of talcose schist, and from this point till the appearance of the limestone as a thin band under the Tertiary rocks the section shows nothing of peculiar interest.

The many acute windings of the road make it difficult to note the proper sequence and dip of the rocks (unless the examination be made on foot, which, in this instance, was not the case), and it is only when the Silurian limestones appear for the last time that interest is afresh aroused. The limestones on the lower slope of the range dip to the westward at high angles, but show a thickness of little more than 100ft. till they are overlain by Tertiary calcareous rocks, which continue down the slope 800ft. These Tertiary or Cretaceo-tertiary beds are full of fossils, and also have the coarse oolitic structure which characterizes the first calcareous beds that overlie the coal-beds at Picton, Cape Foulwind, and at the junction of the Inangahua, in the South Island, and at Whangarei and Kawakawa, in the North Island.

The plan and section accompanying show the boundaries of the principal divisions of the different formations present in the Pikikiruna Range, and (in the section) the manner in which they follow and are related to each other.

Except as above described, I made no examinations away from the main road, and, while I might with some degree of certainty have mapped the boundaries to a greater distance from the road-line, this was unnecessary, since the whole district was examined and mapped by Mr. Park last year.

ON THE PROSPECTS OF COAL NEAR OTAKAIA, OTAGO.

Report by Alexander McKay, F.G.S., Assistant Geologist.

Wellington, 5th September, 1890.

Introduction.

As directed, I went from Dunedin to Otakaia on the 9th December last, and examined the various indications, and shafts and workings made in search of coal on the property of Mr. Blair, at Otakaia, and have the honour to report on the same as follows:—

Report.

The rocks in the immediate vicinity of where prospecting has been carried on have all the appearances of forming part of and belonging to the coal-formation of Green Island and Kaitangata. Between the range at the back of Greytown and the ridge of old rock extending north-east from the Taieri Gorge, near the mouth of the river, the coal-bearing rocks form a syncline. Where the rocks forming this rest on the south-east slopes of Allan's Range, at the back of Greytown, thin seams of coal are known to exist;

and a seam of 1ft. in thickness was prospected on Mr. Palmer's land, but, not improving in thickness, further prospecting has been discontinued.

Further to the south-east, and near the centre of the syncline, for some time back prospecting has been carried on on Mr. Blair's farm. Three shafts have been put down, the deepest of which is about 60ft.; and in one a borehole has been put down from the bottom of the shaft some distance further—15ft. or 20ft.—but without deciding definitely the presence or absence of coal; and when I visited the place it was under consideration whether this should be carried to a greater depth, in the hope of cutting a seam of workable coal.

From the disposition of the strata forming the coal-measures, and the contours of the hills within Mr. Blair's property and immediately adjoining, it appeared to me that prospecting by bore or shaft was not the readiest method of determining the presence of coal. A deep gully runs along the eastern boundary of Mr. Blair's farm, and along this almost the whole of the beds belonging to the coal-bearing series are exposed in succession; and, finally, the bed-rock of old slate can be found by following down the gully.

A little intelligent prospecting along the western slope leading into this gully would result in the discovery of a coal-seam if present; and, as this proved thick or thin, in such manner and to a like degree would it affect the prospects of a workable seam being present on Blair's farm. This course I advised before proceeding further with the works undertaken, which are at present at a standstill.

The strata passed through in the various shafts are a fine-grained sandstone, associated with which are beds of quartz-grit and schistose slaty breccia. Towards the base of the series the grits and breccia-beds are associated with beds of sandy shales and fireclay, in which latter fragments of carbonised plants are of frequent occurrence; but nowhere are there appearances of a definite seam of coal—at least, I saw none within the limits passed over when I last visited the locality. And I could not advise the prosecution of the works already begun on Mr. Blair's farm.

There is every reason to conclude that the beds here forming a syncline between the Palæozoic rocks on either hand—at least, the lower part of them—belong to the coal-bearing series of eastern and south-eastern Otago; but in respect to the higher beds there may possibly be a doubt. Those near and at the back of Otakaia are conglomerates and coarse breccias, formed of fragments of schistose rock. To the south-west of Blair's farm these upper beds, which to all appearance are quite conformable to the lower beds, form a massive angular but loosely-compacted breccia, which has all the appearance of being of glacier origin. These beds have a remarkable development between Henley and the Taieri River, in the gorge east of the Taieri Plain, and here, as at Otakaia, the breccias rest conformably on others resembling or identical with the coal-measures of Green Island and Kaitangata. The same breccias continue to the south-west, and form a ridge of hills as far as a point east of Waihola Gorge. The beds have been previously examined and reported on, but no definite and satisfactory conclusion has been arrived at as to their age and origin. What proofs there are seem to point to a late Miocene or Pliocene age for the beds, but further examinations will have to be undertaken before this point can be settled definitely.

ON THE PROSPECTS OF FINDING COAL ON ROWLEY'S FARM, NEAR SHAG POINT RAILWAY-STATION.

Report by Alexander McKay, F.G.S., Assistant Geologist.

Wellington, 8th September, 1890.

The boulders, gravel, sand, and clay which, together with the coal-seams present, go to make up the various strata of the Shag Point coalfields are of very great thickness at some places, and not so thick at other places. That part of the whole which in place is lowest and rises highest on to the Horse Range is called a breccia-conglomerate, which, being interpreted, in ordinary language signifies a regular, or irregular, higgledy-piggledy, pell-mell, and confused mixture of sharp-angled or partly-rounded pieces of stone, mixed with sand, clay, mud, or anything else that would fill up the spaces between the bigger pieces of stone.

There is a lot of this conglomeration to the east of the main road across the Horse Range, and along both banks of Trotter's Creek after passing the top of the hill on the way from Palmerston to Oamaru. Along the ridge and south-west slopes of the range beds of this kind are found as far to the south-east as Pukeiwitai, and it is here that the topmost part of the breccia-conglomerate shows at the surface, on this side of the Horse Range. This upper part is more sandy, with small and well-rounded quartz pebbles, and there are only a few places at which the rougher conglomeration can be seen.

Over and on top of these sandy beds there are some beds of clay and white sand. The clay beds are hardened, and can be split into thin or thicker slabs, and when clay is so or will do so it is called a shale, and near Pukeiwitai such beds should be called a sandy shale. Mixed up with these sandy shales there are some seams of coal.

Some of those coal-seams are so thin that it is not worth while mentioning them here. There are two coal-seams that might be worth looking at. The lower of these two is not very thick, and as a coal the greater part of it is not worth bothering about. The other, the highest seam, is a little nearer the scar of the hill, which from the outcrop of the seam rises nearly straight up to a great height. This upper seam has a greater thickness of coal of fair quality, and pretty well the whole of it will burn. It is described in a report by the late Sir Julius von Haast as being 3ft. 9in. thick. The seam is not lying flat, neither is it straight up-and-down, nor is it exactly half-way between these two possible positions, but is a little under half-way between the mitre angle (45°) and vertical (90°), having an inclination to the horizon of 64°; and, having this pitch, dip, or inclination to the horizon, it goes down under a lot of other beds on the west side of it, and which are yet to be spoken of, and it (the seam of coal) is no more seen till it appears on the other side of the valley that lies between Pukeiwitai and Mount Vulcan. On the east side of the valley the coal comes to the surface on the east side of a ridge of lower hills that flanks the lower slopes of Mount Vulcan, but which is separated from Mount Vulcan by a deep gully.

Science, but more especially common-sense, persuades us that the seam of coal could be found, by digging a hole deep enough, at any place in the valley that lies between these two hills—*i.e.*, Pukeiwitai and Mount Vulcan. Taking common-sense for it, Mr. MacIntosh, of Shag Point, during the summer of 1885–86, did, with boring-rods, try to make a hole deep enough to reach the coal which he was convinced must be present underneath the road and railway-line near the Pukeiwitai Hotel.

But something went wrong with the hole, with the rods, or with the sheathing used to protect the hole from falling in, and his only reward was a plentiful supply of clear, cold spring-water, not having reached by 100ft. the depth at which I calculated the coal could be cut. After the hole stuck on him, Mr. MacIntosh bothered about and fought with his difficulties for some time; but the running sand and water were too much for him, and the work could not be proceeded with, and so he gave that hole up altogether and went elsewhere. On the opposite side of the valley he was more successful in finding coal, at what is now called Allandale.

Between Pukeiwitai and Mount Vulcan the beds above and immediately below the coal form a syncline. On the west side of this the beds have the high dip already mentioned, while on the east side the dip is more moderate, not being over 30°, and is to the westward. They thus form a syncline. To illustrate a syncline, and to better show what, in a geological sense, is meant by the term, an onion is required—at least, this vegetable is very suitable for the purpose. Having procured a bulb—one as round as it is possible to get—cut it vertically into two equal parts. Then, at right angles to the plane of the first intersection, and at any point between the equatorial and polar regions of the hemisphere selected, make a second cut in a latitudinal direction, and by carefully examining the section exposed by the last application of the knife the meaning of a syncline, and what is to be understood by it, will be apparent. This would be a regular syncline. Synclines are of various kinds, regular and irregular, and so are onions, especially shalot onions; and there is hardly any kind of syncline that may not be illustrated by some kind of onion.

The Pukeiwitai–Mount Vulcan syncline belongs to the irregular class. At first it is rather regular, but this does not last long. Its sides at first are parallel, then divergent, then returned, and all the time it is lop-sided, due to the dip not being the same on the opposing sides. Next, for a considerable distance, so far as can be seen, it is one-sided, then it is two-sided, as at first; and, finally, towards the north, it loses itself altogether—*i.e.*, it is not to be traced, though you might be very anxious to do so.

Here, and at this time, it does not concern us to trace the syncline beyond the northern part of Katiki Beach, and also the eastern side of it may be left out of consideration. In Pukeiwitai the upper coal-seam has on top of it some sandy beds, and over these lie what is called the younger conglomerate or upper grit-beds. The beds were so called by Von Haast, so that no one would be able to mistake them for the lower beds, called breccia-conglomerate; but anybody can see that they are not the same, because this one is not a breccia-conglomerate, and there are no big sharp-edged stones in it. It is nearly all quartz, and mostly made up of round quartz pebbles, the largest of which are about the size of a man's fist: smaller pebbles and sand make up the rest, and the whole, put together, is about 60ft. in thickness.

The upper grit is overlain by the limonitic sandstone, which is fine quartz-sand formed into a hard rock, and which is rusty-red-coloured owing to the presence of iron-oxide.

The limonitic sandstone has been found at the bottom of the sea; but it was not limonitic then. It changed itself when it came ashore, and then it became limonitic. It could not have been limonitic when it was under the sea, because the salt water would not let it be so. It is of no use saying that the limonitic sandstone never was at the bottom of the sea, because there are proofs to the contrary, there being in it the prints of many kinds of sea-shells, and sometimes the real shell itself. There are also sea-weeds petrified; and these do not now grow on dry land except when the tide is out, and the tide is always out on Pukeiwitai. These and a lot of other things show that the limonitic sandstone was made at the bottom of the sea. From the top of these beds to the coal I estimate the thickness to be from 150ft. to 200ft.

Katiki Beach beds, which are 350ft. thick, lie on top of the limonitic sandstone. They are full of boulders; but these boulders are not the same as those found in the breccia-conglomerate mentioned at the beginning of this report. The Katiki Beach boulders are not Moeraki boulders, although, except in colour, they are very like them. They are far more numerous, and are of all shapes and sizes. Some have bones in them. Sometimes the boulder is very hard and quite round; sometimes it is smashed up into a lot of small pieces; and sometimes the boulder is not there at all, but only the place where it sat in the dark sandy clay that forms the greater part of the Katiki Beach beds. The Katiki Beach boulders are called concretions, and Professor Hutton says they are ferruginous concretions, while the Moeraki boulders are not. I should like to argue that point, because I do not believe that either the one or the other were ferruginous when they first formed themselves, and you can find them brown at both places if you look for them; but if you only want grey ones you can find them at Moeraki, and if you want rusty-brown ones you can find them on Katiki Beach, and you can have it the other way about also. But for all that I do not believe that the Katiki Beach boulders are Moeraki boulders, because they have never been to Moeraki, but both are concretions without doubt.

A concretion is something that has gathered itself round about something else: sometimes there is nothing for it to gather about, but that does not prevent its being a concretion all the same, only there is no foreign substance in its heart. This foreign substance at its heart is supposed to act as an inducement to make the concretion come round about it. The concretion, when it is finished, is composed of carbonate of lime and some clay, with a little iron in addition if it is to be a ferruginous concretion. These concretions are very abundant in the Katiki Beach beds.

The Katiki Beach beds themselves, over and above what has been just said of them, are sometimes of a dirty-green colour. They are at the surface all over between the lower slopes of the Horse Range and the sea-shore south of the mouth of Trotter's Creek.

Just behind the Shag Point Junction Railway-station the Katiki Beach beds lie in against the foot of the range, and rise some way on to the steep slope of the highest ridge of the hill. Until this steeper slope of the hill is reached the beds may be supposed to be resting nearly flat, or inclined at but moderate angles towards the east; but they curl up suddenly, and, leaving the boulder-beds all of a heap at the bottom or on the lower part of the abrupt slope, the limonitic sandstone and the upper grit-beds occupy the whole of the ridge to its highest point. The coal is just to the back—*i.e.*, to the westward of the crest of the ridge—and it can be found by making a tunnel into the hill, or by sinking a shaft or borehole at the foot of the range, or by simply going to the place where it outcrops to the surface.

If a hole were sunk at the foot of the steep part of the range it would probably have to be put down 300ft. or 400ft. before it got to the coal. If from the same point a drive were put into the hill, before the coal could be reached it is probable the drive would be longer than the depth of the hole would be if the plan of sinking were adopted. But neither the shaft at this place, nor the drive, would be any good for making a coal-mine, because the drive would cut the coal where the seam was highly inclined, and the coal above hand to the outcrop would not be a great quantity, and would be less than that, *i.e.*, a great quantity, because the seam is not very thick at this place. The coal would probably be thicker at the bottom of the shaft if that were put down; but that coal which lay to the west would not be worth troubling about, while in the direction in which workable coal might be expected it would be all downhill work, and it would be difficult to make that pay.

To do the thing properly a hole should be sunk somewhere between the railway-line and the sea-beach. A hole placed in such a position would probably be very deep* before it cut the coal-seam, but at the same time it would have the advantage of piercing the measures at a place where they are lying flat, and whence the coal could be worked to advantage in every direction, north, south, east, and west.

Of course, it must be kept in mind that it is not quite certain that the coal will be there when the hole is sunk to the depth mentioned, and, if there, it may not be thick enough to be a recompense for all the trouble and labour that the sinking of the hole has cost. It is very likely that a seam of coal of some kind is under the Katiki Beach beds at the place above indicated, but how thick it is no one can say. Its probable thickness can only, before sinking, be arrived at in this way: On the western side of the syncline the coal is, in Pukeiwitai, 3ft. 9in. thick; west of the Shag Point railway junction it is 1ft. 6in.; and in Terapupu Valley the thickest seam is about 12in. On the other side of the syncline the seam worked at Allandale is 5ft. thick, and at Shag Point Mine as much as 11ft. of coal has been worked. Therefore on one side of the syncline the average thickness is 8ft., while on the other it is just over 2ft. This gives an average 5ft. of coal in the middle of the synclinal trough; but, as the position indicated as being the proper place to bore at lies on the western side of the axis of the syncline, and that is the side on which the seams are thin, it is not likely that the seam will be as much as 5ft. thick, and it is just possible that a thickness of 3ft. will hold it.

Some attempts have already been made to prove the presence of coal a distance further on towards the north end of Katiki Beach. The hole was commenced in the Katiki Beach beds; it was put down till it was between 300ft. and 400ft. deep, and then

* The total thickness of the beds is given as 550ft., and in the trough of the syncline coal should be found at a depth not greatly exceeding the estimated thickness of the beds. On the west side of the syncline, as the beds acquire a higher dip, the depth to the coal would be increased, though denudation again would lessen the thickness of strata present. [Since the above was written a borehole at the railway junction has cut the coal-measures at about 400ft.]

it stuck, like the other hole, at Pukeiwitai. At all events, they did not stick to it. And that is all that has been done. It is a good thing to know that it is probable that coal would be found in a hole that could be got down deep enough, but, for all that, I could not recommend any one to put down such a hole, if this is done with a view of making money out of it. It might be all very well if he did it just to see whether there was any coal there, but with a view to making a fortune out of it I do not think I would try.

ON THE QUARTZ REEFS OF THE NENTHORN DISTRICT, OTAGO.

REPORT BY ALEXANDER MCKAY, F.G.S., ASSISTANT GEOLOGIST.

Wellington, 15th September, 1890.

INTRODUCTION.

As directed, on the 18th December, 1889, I left Dunedin for Nenthorn, by way of Palmerston and Shag Valley, and got there the evening of the same day. On the 19th I examined different mines and outcrops of reefs in a direction south of the township, and on the following day those to the northward and in the direction of Macrae's Flat. On the 21st I purposed examining the country in the direction of Hummockside and the Stoneburn, with a view to the discovery of coal—much needed at Nenthorn; but thick fog prevented this work being done. And the following day, with the same object, I examined the country more to the south-west; but without making any discoveries indicating the actual existence of coal-seams. On the 24th December I returned to Dunedin.

REPORT.

The Nenthorn reefing district seems to form part of a much larger region over which auriferous lodes and the ores of other metals are found.

This, even within bounds less than the actual limits, may be said to extend from Highlay Hill, by way of Macrae's Flat and the Nenthorn valley, to the Taieri River, and thence in a direct line to the Upper Waipori, where gold, copper, and antimony lodes are known, and are being—or have been—worked.

Within this belt of country the reefs, with few exceptions, trend nearly E.–W., and dip to N. at high angles generally, although in the amount and direction of the dip there are also a few exceptions to the general rule. There seems to be no definite limit to the reefs in the direction of their strike, the limits of the mineralised country in an east-and-west direction not yet being determined.

To the eastward reefs are found in the schistose country till where this disappears under the Cretaceo-tertiary rocks developed along the coast-line of eastern Otago. To the westward it is reported that quartz reefs of a similar character, and trending in the same general direction, are not rare in the Taieri Ridge, on the east side of Strath-Taieri, and in all probability the same system of fissures and reefs is to be found in the Rock and Pillar Range, on the opposite side of the valley.

While thus the belt of country over which reefs are found has a considerable breadth, there is, on closer examination, every probability of the reefs being equally continuous in depth. An impression, amounting to an apprehension, exists that, because the reefs are of no great thickness, they will not continue in depth; but, so far as the mines have been worked, there seems to be no ground for this, and, so far as the sectional features of the country lay bare and expose the reefs in a vertical direction, the evidence so to be obtained confirms and supports the conclusion to which the work done in the mines leads.

Almost all the reefs — and their number is great — carry gold. Some yield remarkably rich specimens, while others, though not showing gold freely to the unaided eye, yet give very encouraging returns on analysis, or on being crushed and panned off by the ordinary means available at the mine.

The least encouraging feature in connection with most of the reefs that have been found and are being worked is their thinness, few of them exceeding 14in. in thickness, and, so far as I could determine, the average thickness is not more than from 12in. to 15in. Along the outcrops and shallow workings that have been made, the reefs as a rule are of uniform thickness, and it is in the vertical direction that they tend to be variable. This is due generally to a roll in the foot-wall, causing a flattening of the dip, or the reverse, while the hanging-wall continues even, and has a uniform inclination.

Pyrites, as iron-sulphide, abound in most of the reefs. These are of two kinds, the most abundant being dark-grey, and in minute crystals, having a powdery appearance; the other is the ordinary yellow crystal, occurring as cubes of moderate size, dispersed throughout the stone. Antimony, as stibnite, is also present, and occurs rather plentifully in the Home Rule Claim. Zinc-blende occurs sparingly in the same mine; and two other minerals, probably resulting from the decomposition of stibnite, were also collected, but the exact nature of these has not yet been ascertained. From Mr. Kitchener I learned that zinc-blende and galena occur in some of the mines to the north and north-east of the township.

In the Victoria and Blue Slate Mines the quartz is often stained by silicate of copper, but I could not detect the presence of copper-pyrites, or any of the other sulphides of copper. When the mines are worked to a greater depth than at present these are likely to appear. Fragments of schistose slate are often included in the quartz of these mines, and usually such inclusions are of a green colour, due to the presence of copper as a silicate. Manganese is present in some of the claims, and occurs as an oxide in a powdery form, staining and filling cavities in the quartz. In this form it occurs in the Daisy Mine, lying to the north of the township. Manganese in another form occurs within the ground held by the Victoria Company. Near the southern boundary of that company's ground there is about 2ft. of rhodonite, interbedded with quartz, in the slaty schists showing at the surface in that direction.

Coal is known to occur on the west side of the Stoneburn watershed, about ten miles from Nenthorn; and, if it turns out that no deposits of this kind can be found nearer the mines, this will have to be worked for the supply of the field. I spent two days in the hope that I should be able to indicate a locality nearer at hand where coal might possibly be found, but, so far as I could see or judge, only the lower grits were preserved at the localities examined, and these are preserved only by being overflowed by basaltic lavas, as is the case farther to the east, between Stoneburn and the upper part of Pleasant River. The quartz-grits thus covered and preserved lie to the south of the township, and I think are worth prospecting for gold, which I doubt not will at places be found in the loose quartz gravels and cements of which these lower beds of the coal-bearing series are composed. I am strengthened in the opinion here expressed by the observation that where these gravels are present, at one place, gold has been obtained, and the ground worked where the gold was likely to have been released from the grits and cements on the hill-side above, and simply gravitated into the low grounds where the old workings are. Those who worked the ground must have come to a similar conclusion as to the whence of the gold they obtained, because by a series of holes they seem to have traced the run of gold to the outcrop of the quartz grits and cements *in sitû*, and the last hole, apparently, has been sunk in the grits themselves; but for some reason or another this has not been bottomed, but there can be no doubt there was sufficient warrant for commencing the hole, and it should have been proceeded with till the bed-rock was reached, nor should I have been satisfied with putting down a single hole, even if that yielded no gold.

That these gravels and cements are auriferous at many places in this district is well known, and wherever diggings of any value have been they are always to be found in their near neighbourhood; while, on the contrary, where they are absent from any considerable area, within that area little or no payable alluvial gold has been found: and the Nenthorn reefing district is not an exception to this rule.

Over the most of this the quartz-drifts have been removed, and probably a considerable thickness of the schistose bed-rock also, with the result that the alluvial banks and beds of the creeks draining the district are generally poor in gold. This is the more remarkable on account of the number of reefs carrying gold, and of the destruction of the outcropping parts, of which the fragments strewed over the surface or embedded in the soil yield gold fairly; but from such source little or scarcely any free gold has made its way into the creek-beds; and this absence of paying gold in the creeks leads to the inference that either the quartz-drifts, which undoubtedly once overspread the district, did not contain much alluvial gold, or this by some means has also been removed.

This comparative absence of alluvial gold from the creek-beds of the district is matter of much surprise and a cause of no little speculation among the more intelligent of the miners on the field; and the opinion is prevalent that the gold, as rapidly as it is set free, is dissolved and carried away by chlorinated waters. Whatever the facts may be, no attempts have been made to show that this is the true theory of what is undoubtedly a remarkable circumstance.

Most of the reefs strike E.–W., and dip to N.; but there are at least two exceptions to this rule. The Victoria reef, close to the township, strikes E. 25° S.; and Jacob's reef, a mile and a half to the north, trends in the same direction. South of the township some of the reefs dip to S., as seen in the Glenken's lease; but in the Home Rule, a little farther south, the dip of the main reef is again to N. These variations from the general strike and dip are exceptions, and, so far as yet ascertained, most of them dip as above stated.

It has been said that the reefs are thin; and it will be quite safe to say that nine out of every ten reefs are under 2ft. in thickness; but there are here and there bodies of quartz of considerable thickness. On Lot's Wife Claim the reef is reported as being 4ft. wide, and showing fair gold throughout. This claim is on the top of the range overlooking the Stoneburn. I did not visit the mine. Close to the Township of Nenthorn there is a massive outcrop of white quartz, which is called a "buck reef," and held in much disfavour by the miners, but for what reason, other than its great size, I have been unable to make out. It has certainly never had a fair trial.

The rocks in which the reefs are found may be regarded as forming part of the middle division of the schistose rocks of the goldfields of Otago, as they underlie the upper or arenaceous schist of the Taieri and Shag Valleys, and only here and there do they show the characteristics of the lower contorted schist, which, apart from its other distinguishing features, is generally of a calcareous character.

A system of north-and-south joints cut all the metamorphic rocks of the field at frequent intervals, and these joints greatly facilitate the production of the numberless castellated crags that stud and give a peculiar character to this and other parts of central Otago.

These north-and-south joints carry no lodes or mineral deposits of any description. Nearly at right angles to the north-and-south joints there is another set running nearly east-and-west, and it is these that carry the auriferous lodes that are in course of being developed. The fissures which the reefs now fill being due to causes which have affected a great area of country, I have every confidence that the lodes will continue to depths as great as the means to follow them will admit of; and, provided the thickness of the reefs and the percentage of gold present be sufficient, the permanence of the field as a reefing-district will be assured.

ON AN OUTCROP OF ANTIMONY ORE ON BAREWOOD RUN, TAIERI RIVER, OTAGO.

REPORT BY ALEXANDER MCKAY, F.G.S., ASSISTANT GEOLOGIST.

Wellington, 17th September, 1890.

DURING the first week of February I visited an outcrop of antimony ore on Barewood Run, sixteen miles north of Dunedin. This outcrop occurs within the watershed of Three o'Clock Creek, about two miles and a half above its junction with the Taieri. A quantity of the ore stibnite was displayed in the Mineral Court of the Dunedin and South Seas Exhibition, and this, appearing to indicate a lode of some importance and value, was the occasion of my visit to the locality and outcrop of the lode.

On arriving on the ground I found that the ore extracted and sent to Dunedin had been obtained from an open working about 30ft. in length and some 12ft. deep. The walls of the lode could be traced west from this opening for some distance, but the ore-band in this direction was thin and of poor quality, and in the deepest part of the workings the rib of ore seemed also to have thinned considerably, but, from the presence of water, the deeper parts of the workings could not be examined in a satisfactory way.

Considering the excellent show made in Dunedin by the exhibition of some four or five tons of high-class ore, the results of my examination on the ground were somewhat disappointing; yet it must be said that the lode has in no sense been opened out so as to prove its value, and that it would be ill-judged to condemn it from what is to be seen at the surface.

The lode dips to N.W., and in this direction, a short distance from the main open working, nests of antimony ore are found in the schistose rock which do not appear to have any connection with a lode. One such elliptic mass yielded ore amounting to a ton or more, but, this exhausted, nothing further could be traced at that place.

What is wanted to prove the worth of these deposits is systematic and intelligent prospecting of the district, and, no doubt, the support of a little capital to enable the work to be continued long enough to prove the field.

ON THE PUHIPUHI SILVERFIELD, AUCKLAND.

Report by Alexander McKay, F.G.S., Assistant Geologist.

Wellington, 20th September, 1890.

Introduction.

On the 19th of March last I went from Kawakawa to Puhipuhi, and examined the different lodes and outcrops of metalliferous reefs in the Prospectors' Claim, but the weather proved so inclement and continuously rainy that no work could be done, and after a stay of three days I left the district, hoping to be able to pay a second visit under more favourable conditions before returning to Wellington. Unfortunately, on my return from Whangaroa and Mongonui the weather was worse than before, and other matters prevented my paying the intended second visit to the Puhipuhi district, or that more to the north-east in the direction of Cape Brett.

Report.

Between Whangarei Harbour and the Bay of Islands the country along the coast is mountainous, and is mainly formed of Palæozoic rocks of Carboniferous or Devonian age. Cretaceo-tertiary rocks are present in the southern part of the district, and volcanic rocks of a yet later date also over considerable areas overlie and obscure the Palæozoic rocks. The central high lands within Puhipuhi Forest form a table-land of volcanic rocks, the slopes from which to the lower grounds on all sides expose the older slates and sandstones, &c., which carry the silver-bearing reefs. Quartz-reefs occur and are abundant in this older formation from Hikurangi to Cape Brett, and within Puhipuhi Forest many of these have been proved to bear silver, and recent tests, as reported, show that some of them are auriferous also.

The first discoveries were made in the northern part of Puhipuhi Forest, nearly east of and about four miles distant from the eastern base of Ruapekapeka Hill, and it was here the greatest activity, in testing the value of the field, was being displayed when I visited the district. This also was the only part within the forest examined by me, as I did not reach the vicinity of or examine the claims in the southern part of Puhipuhi Forest.

Nowhere except in the Prospectors' Lease had such sufficient work been done as enabled any judgment to be formed as to the precise character and probable continuity of the reefs, and my work consisted chiefly in determining the nature of the rocks which carry the reefs.

From the table-land forming the central part of Puhipuhi Forest the descent to the westward is abrupt, and on this side from under the volcanic sheet the silver-bearing rocks are exposed, first as a steep slope broken by gullies, and afterwards, more to the west, as rugged hilly country gradually descending to the low grounds.

The rocks of the older formation carrying the reefs are here gritty sandstones and slates, the latter often of a green colour; and there is also a tufaceous-looking rock of a green colour, which decomposes readily to a considerable depth into a white clay. These rocks have often been spoken of and mentioned in the reports of the Survey as diorite sandstones and aphanite slates, and, together with considerable bodies of cherty rock, they are well seen on the old road from Whangarei to Kawakawa between Ruapekapeka Hill and Kawakawa. So far as yet known there are no crystalline or intrusive rocks present in this formation between Whangarei and the Bay of Islands; but in other parts to the north and west in Hokianga and Mongonui Counties there are great developments of a fine-grained diorite, and at other places interbedded lavas and tufa-beds are associated with these rocks. The formation is often slightly calcareous, but only at one place, on the coast opposite Stephenson's Island, are solid and massive limestones to be found.

The readiness with which these rocks decompose is well illustrated by the sections that can be seen and studied near Kawakawa, along the banks of Waiomio Creek, and in the heavy cuttings along the railway between Kawakawa and Opua. On the exposed sea-coast the same rocks do not present this appearance, the proceeds of decomposition and denudation being more rapidly removed. Red slates, jasperoid and grey cherts, with green aphanite, ash, or tufa beds, form a natural division or series as part of this formation, but whether the highest or lowest has not yet exactly been determined; but, so far as I can judge, they form the middle series of the three into which the formation might be divided, and this is in accordance with what has been ascertained of the same formation in the vicinity of Wellington and in the Rimutaka and Tararua Ranges, and the same rocks continued north-east to the Bay of Plenty. These rocks can be seen well displayed in section in the gorge of a small stream passing the sawmill at Hikurangi, and here, not being decomposed as at Puhipuhi, they can be studied to advantage.

Near the cluster of claims and holdings surrounding the Prospectors' Lease there is on the western slope from the central table-land of volcanic rocks a very massive development of grey cherty rock running about north-and-south. This at places is heavily charged with iron-pyrites, and by the bulk of the prospectors on the ground is regarded as a massive and the principal reef of the mineralised part of the district. As yet, speaking of the time of my visit, this has failed to yield either gold or silver.

Elsewhere this rock usually yields a trace of gold, and it would not be surprising if in the Puhipuhi district it yielded both gold and silver, and therefore it should not be wholly overlooked by prospectors. But it has little similarity of appearance to, or kinship with, the quartz reefs which are being prospected and worked for silver.

On the west side of this great band of chert the rocks are grey or greenish sandstones and the green aphanite, ash, or tufa beds already mentioned, and it is these that carry the silver-bearing reefs. In the bottoms of the deeper gullies and gorgy water-courses these rocks are in their normal condition; but in the ridges and spurs adjoining they are decomposed to a white pipe-clay, or to such intermixed with patches or bands of a ferruginous colour. Undecomposed there is an abundance of pyrites in this green rock, and the oxidation of these appears to be the starting and principal cause of the surface decomposition of the rock. The greater number of quartz-reefs intersecting this rock trend between north and north-west; but that known as Prospectors' No. 1 trends in a nearly east-and-west direction, and dips at a high angle in a south direction. The quartz forming the reefs is also somewhat peculiar in character, and consists largely of thin plates of quartz covered with minute crystals of the same. This variety of quartz usually occurs on the hanging-wall side of the reef, while towards the foot-wall side the quartz is more solid and compact. Most of the quartz is of a light-grey or cream colour; but in several of the reefs the quartz is stained and the cavities are filled with iron oxide, which gives to the outcrop a rusty-brown colour. Where cropping to the surface, and exposed to the weather, the reef-quartz is of a clear or milky white. In one reef only did I notice iron-pyrites present in any quantity, and this only where overflowed by the waters of the small creek passing the prospectors' camp. Where the containing rocks have been highly decomposed, the quartz, on being worked into, is covered by a white siliceous paste, either the result of precipitation or of infiltration, which leads to the belief that the cavities in the quartz are gradually being filled up in this manner.

No. 1 shaft on the Prospectors' Lease had at the time of my visit been sunk to a depth of 60ft. The reef was between 3ft. and 4ft. wide, but was divided near the bottom of the shaft by a "horse." The stone being sent to the surface was of the character already described, with a fair quantity of iron-oxide in the cavities. At the bottom of the shaft there were appearances that the oxidized and decomposed surface-rocks were nearly passed through, and at greater depths it was evident that the green aphanite or tufaceous rock undecomposed would soon be entered on.

The nature of this rock is well seen in a low-level tunnel driven, from the level of the creek, into the spur on which No. 7 shaft is situate. At a short distance from the entrance the walls of this tunnel show the green rock undecomposed, with patches of ferruginous-coloured rock where pyrites have abounded, or where a joint has afforded the means for the drainage of water. Towards the inner end of the tunnel these rusty-coloured patches were fewer, and the rock was mostly of a leek-green colour.

In the Creek Valley above the camp, stone was being stacked from two tunnels in which reefs had been cut, but neither of these heaps nor the quartz in the face of the workings showed anything but a trace of silver-ore on mere examination of specimens. At No. 1 shaft the case was different, and here the ore showed freely in the stone. From stone that was at the moment being brought to the surface I selected four samples, which I forwarded to the Director of the Geological Survey at Wellington. These samples, on analysis, gave the following returns: Sample No. 1 gave at the rate of 352oz. to the ton; No. 2, at the rate of 236oz.; No. 3 gave 65oz.; and No. 4, 13oz. to the ton of stone,—the average yield thus being at the rate of 167oz. to the ton.

The silver-ore occurs as small crystals disseminated through the stone, and the concentration of the ore to such a grade as will pay to transport it to reducing-works at a distance, or even for treatment at works that may be erected on the ground or in the vicinity of the mines, is likely to prove a costly and, except for the richer parts of the lodes, perhaps not a paying process. Hand-dressing seems to be out of the question as regards such ore as was being brought to grass at the time of my visit, as it was hard to say that any part of the lode was richer than another.

From Russell I went to Rawhiti, on the western side of the rugged mountainous country between the approach to the Bay of Islands and the coast-line to the south-east. Prospecting has been carried on at Rawhiti for several years back, and the recent discoveries at Puhipuhi had excited fresh interest in this locality. At the old prospecting drive I could discover no distinct reef of quartz—only a network of small veins intersecting the sandstone, which contained them, in all directions. An old drive, which had fallen in, showed at its entrance about 1ft. of quartz heavily charged with pyrites, and traces of antimony-ore (stibnite). Samples of this ore from the lower drive had on a former occasion been forwarded to Sydney, and these, I was informed, yielded both gold and silver; but the samples selected by myself, and analysed in the Colonial Laboratory at Wellington, yielded neither gold nor silver.

To the south and south-east of Rawhiti a great number of small quartz-reefs are to be found in the hills, and one reef about three miles to the south-east was 4ft. wide, and heavily charged with pyrites. Samples taken from this, and from several smaller reefs, were analysed, but yielded neither gold nor silver.

While, so far, prospecting at Rawhiti and in the direction of Cape Brett has not been productive of the desired results, it is still to be noted as a favourable fact that the distance from Puhipuhi is not great (about fifteen miles), and that the country and quartz-reefs are of exactly the same character, so that there are still reasonable hopes of tracing the silver-bearing lodes into this part of the district, over which the older rocks of Palæozoic age are found intersected by quartz-reefs.

ON THE PROSPECTS OF COAL AT PAKARAKA, BAY OF ISLANDS, AUCKLAND.

Report by Alexander McKay, F.G.S., Assistant Geologist.

Wellington, 30th September, 1890.

Coal-bearing rocks extend over the greater part of Bay of Islands and Hokianga Counties, and occupy large areas within Whangarei and Hobson Counties, and altogether this is the most extensive continuous area of the Cretaceo-tertiary formation carrying coal-seams that occurs anywhere in New Zealand.

Workable coal, however, is found only at a few places—at Kamo, Hikurangi, and at Kawakawa. Seams of coal are reported as occurring at other places—as, for instance, east of Kamo, and at Hukerenui, and along the Mangakahia River, &c. These, however, are either too thin to work, or are so situated as to be unworkable at the present time; and, looking at the whole field, its prospects are not of the most satisfactory kind. The gradual exhaustion of the Kawakawa Mine, and the unsuccessful attempts to discover an extension of the workable seam at that place, has naturally led to apprehension as to the future of coal-mining within the Bay of Islands County, and at the same time have stimulated prospecting in other parts of that particular field, and in adjoining areas.

At Waiomio, where there is a possibility of coal-seams being present under the Whangarei limestone and lower greensands, the difficulty of making proper and definite arrangements with the Natives has retarded the prospecting and development of that part of the field. In the deep ground west of the Kawakawa workings, and on the Scoria Flat, all attempts to find workable coal have proved unsuccessful, and as yet no better success has attended prospecting at Turntable Hill, at Waimate, or at Okaihau.

Notwithstanding these repeated failures there is still a strong and widespread conviction that workable coal-seams are to be found within the county boundaries at other places than at Kawakawa, and for some time past the north-west slopes of Turntable Hill and the downs and low hills north-east of the road-line between Turntable Hill and Pakaraka have absorbed the chief interest and attention in this respect.

During the past season, while in the North of Auckland district, I was instructed to examine the country between Turntable Hill and Pakaraka and to the south of Pakaraka, in order to ascertain definitely what rocks of the Cretaceo-tertiary series were present, and what the probability of coal being present in that part of the district.

At Kawakawa the rock forming the roof of the coal is a greensand, easily recognised wherever it may occur. This is overlain by the Whangarei limestone, a rock not always present in other and distant parts of the field, but wherever present easily recognised by unmistakable characteristics. This in turn is overlain by the siliceous firestone and flint beds, followed by the hydraulic limestone, the upper greensands, and the grey-marls. All these beds follow each other in due succession in the section west from the Kawakawa Mine, and, from the hydraulic limestone to the coal, they have been proved in vertical superposition in the boreholes put down in search of coal on the dip-side of the present workings.

From Turntable Hill north-west to the road leading from Pakaraka to Black Bridge and the Waitangi the lower greensands are fully and clearly developed, and, though the Whangarei limestone is here absent, the greensands are followed by the firestone and flint beds that underlie the hydraulic limestone, and by the hydraulic limestone itself.

There cannot therefore be a doubt that the greensands which in this district are found underlying the hydraulic limestone and flint and firestone beds are the same as, or the equivalents of, the greensands that cover the coal at Kawakawa. Such greensands appear at Waiomio, at Turntable Hill, and thence north-west to the road from Pakaraka to Black Bridge, and south of Pakaraka in the upper valley of the Kawakawa River, and at these places are overlain either by the Whangarei limestone, or by the firestone and hydraulic limestone, or by all three of these divisions of the Cretaceo-tertiary formation.

In the ridge of hills to the north-east of the main road between Turntable Hill and Pakaraka the greensand beds are most favourably situated for prospecting for coal, the dip of the beds being gently to the S.W., while the old rocks of Palæozoic age appear along the north-east lower slope of the ridge. Therefore in the section from the old rocks south-west across the ridge the beds are successively exposed to the highest in the ridge (the flint and firestones), and if coal be present there should be little difficulty in finding the seam.

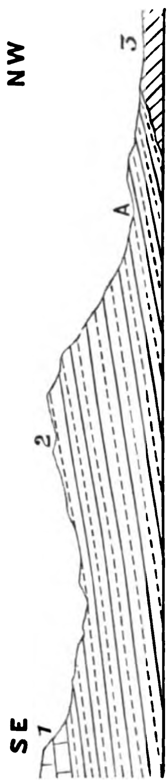
There is, however, some doubt whether the coal is developed in this part of the district. There are some faint traces of coal in the lower part of the greensands on Turntable Hill, but, so far as I could judge, this is of little importance. More to the north-west, in the ridge of hills mentioned, several days of careful search resulted in not a trace of coal or coal-shale being discovered. The greensands appear to rest on the old rock without there being in or under them either shales or coal.

Section from Pakaraka north-east to Morgan's Clearing, showing the disposition and arrangement of the Lower Cretaceo-tertiary beds. 1. Alluvial (Pakaraka Flat). 2. Volcanic (in valley south-west of Morgan's Clearing). 3. Hydraulic limestone and flint-beds. 4. Greensands, with a probability of coal at their base. 5. Palæozoic rock.

Towards the north-west end of this range, and close to the road leading from Pakaraka to Black Bridge, grey quartz sands underlie the greensands, and here it might be possible to prove the presence or absence of coal without having to sink to any great depth.

The small stream running between the north-east edge of the Pakaraka Flat and the range to the north-east, after it crosses the road to Black Bridge, runs for a short distance over Palæozoic rocks,—showing clearly that near the bridge, over the same creek, no great depth of shaft or bore is required to reach the old rock. Had the banks of the creek been less swampy, possibly the outcrop of the lower beds and any coal-seam that might be present would have been displayed or easily discovered: as it is, a shaft or borehole is required to prove the measures. This is shown in the accompanying section.

Further to the north-west a breadth of low land, covered by volcanic rock, stretches north-east in continuation of the low lands around Pakaraka; and



Section of north-west end of range east of Pakaraka Flat, showing the lower beds of coal-bearing strata near bridge at A. 1. Hydraulic limestone and firestone. 2. Greensands. 3. Old rock.

between this and the east bank of the Ngahikunga there is a range of hills, near the southern end of which is an outcrop of Whangarei limestone. This is to be seen on the right bank of a sluggish creek flowing west to join the Ngahikunga, but neither higher nor lower beds belonging to the same series can be observed at this place. About a mile distant, and on the banks of the Ngahikunga itself, another outcrop of Whangarei limestone takes place; and in this latter case the limestone is overlain by the firestone and hydraulic-limestone division of the Cretaceo-tertiary series, and these rocks may be traced continuously north and north-west to the Waitangi River, north and west of Waimate, in which direction they, or the beds immediately underlying, yield Secondary fossils.

From Turntable Hill to the end of the range extending north-west, as already described, is the north-eastern limit of a large development of Cretaceo-tertiary and probably coal-bearing rocks, and it is along this line that they can be most easily prospected for workable seams of coal. More to the south and west the higher beds of the series present, and volcanic rocks in addition, render prospecting a matter of greater difficulty. South of Paeroa, within the watershed drained by the Kawakawa River, limestone and underlying greensands appear along the north side of the valley, and at one or two places it might be possible to reach coal by means of a shaft or bore placed so as to start in the greensands under the limestone. I could not learn that coal had been found in this part of the district; and, as the country is hilly, it might be supposed that the coal would show at the surface in one or other of the many gullies that cut into the range lying between this valley and the low grounds between Pakaraka and Turntable Hill.

North-west of Paeroa, and exposed along the banks of the Ngahikunga, the uppermost beds of the Cretaceo-tertiary series seen are the hydraulic limestone overflowed by volcanic rock. The lower beds of the limestone alternate with thin beds of greensands and some dark shaly beds, in which are ferruginous calcareous concretions. These beds yield large specimens of Inoceramus, and are underlain by the firestone and flint beds that extend continuously down the river until the Whangarei limestone shows from beneath these latter.

The examinations made lead decisively to the conclusion that the beds surrounding Pakaraka belong to and are the same as the coal-measures and overlying strata in the Kawakawa area. The typical rock at Kawakawa—viz., the greensands under the Whangarei limestone—is developed at Turntable Hill, and in the range north-east of the road thence leading to Pakaraka, and it is here undoubtedly that there is the best chance of getting coal at a moderate depth from the surface. It must, however, be distinctly stated that the measures may prove barren of coal, and that the probabilities are not greatly in favour of anything like an important coal-seam being present in this part of the field. Did such exist, indications more than have been discovered should be apparent in one or other of the many gullies that cut into the lower part of the formation.

ON THE GEOLOGY OF THE LOWER WAIKAKA VALLEY, AND THE AURIFEROUS DRIFTS AT SWITZERS DIGGINGS.

Report by Alexander McKay, F.G.S., Assistant Geologist.

Wellington, 5th November, 1890.

On crossing the Mataura River, on the road from Riversdale to Waikaka and Switzers Diggings, the road shortly by a steep cutting ascends on to a high terrace. This lies between the Mataura and the lower part of the Waikaka River, but properly it may be said to occupy the lower part of the Waikaka valley. The surface of the terrace is several hundred feet above the channel of either river. It is triangular in form, the base resting against the ranges to the north in the direction of East Dome and the Nokomai. After ten miles' travelling over this terrace-plain a sudden descent is made into the valley of the Waikaka, and now on its left bank the river is confined by a range of hills formed of subschistose rock, belonging to probably the Devonian period and the Walter and Cecil Peak series of the Survey classification. But to the north-west the lower levels and narrowest part of the valley are still bounded by a continuation of the high terrace-plain just described. This terminating, rolling downs appear on the same side of the valley, and these are formed partly of the same coarse river-gravels that compose the terrace-plains towards the Mataura; but also quartz-gravels of a different type are present. From beneath both kinds of gravel the bed-rock shows at the foot of the terraces, and is well shown in the road-cuttings before crossing the river to the Township of Waikaka.

These rolling downs are the auriferous grounds on the north-west side of the valley, and both the superficial coarse rubbly and underlying quartzose gravels are worked. On the opposite side of the valley, the south-east side, both kinds of gravel are present, and are worked for gold, as also are or have been the recently-formed low-level gravels and river-beaches. On this, the south-east side of the valley, is the Township of Waikaka, and nearly all of the most extensive and important gold-workings of the old Switzers Diggings. The low grounds of the valley, as in the opposite north-west side, are bounded by low hills, on the outer and lower slopes of which old slate and semi-metamorphic rocks make their appearance. These are divided from Round Hill by a deep gully filled with auriferous gravels, which to the north rise into low hills having rounded outlines, and to the south also cling to the north and north-west slopes of Round Hill. There are, as superficial high-level gravels, from 100ft. to 150ft. of coarse rubbly schistose gravels, which at many places are still being worked by the hydraulic method, and these rest on an unascertained thickness of white or brownish quartz-gravels and cements that are also auriferous, but which never appear to have been regarded as distinct from the upper gravels. The block of hills to the east and north-east of the township are isolated from Round Hill and the ranges to the east and north-east by a depression about half a mile wide, and following this the auriferous gravels encircle the eastern slopes of the block of lower hills thus isolated.

At the south-east angle a sort of saddle-ridge connects the lower hills with the ranges to the eastward, and here both kinds of auriferous gravel are present; but further to the north, except loose and recent detritus in the low grounds, the gravels are of the quartzose type.

At several places along the lower slopes of the hills on the west side of the valley the quartz-gravels have been worked for gold. Towards the north-east, where the hills terminate, near the bank of the river, the quartz-gravels are underlain by clays and seams of lignite, which in turn are seen resting on the old rock.

On the western side of the valley fossiliferous beds appear to be associated with the quartz-gravels. A block of this fossiliferous rock from Muddy Creek was forwarded to the Dunedin and South Seas Exhibition, and this, on being broken up, yielded a number of fossils that appear to indicate a Miocene age; but a number of species contained in the block are new, and some indicate a greater age for the beds.

The chief interest in connection with the auriferous gravels of the district naturally attaches to the lower or quartz gravels, which are of the same character as, and probably of the age of, the quartz-drifts of the old lake-basins of central Otago. The more superficial gravels naturally have hitherto been those from which the greater bulk of gold has been obtained, but the quartz-drifts are no less important, and in the future their relative importance will increase: indeed, in the near future they must become the backbone and mainstay of hydraulic mining in Otago. There is hardly a fresh discovery being made in the coarse, rubbly, and superficial drifts, while of late some of very great importance have been made in connection with the quartz-drifts, as, for instance, at Tinker's Gully and other places in the Manuherikia valley.

At Switzers, the quartz-gravels being present as an ample development and being proved auriferous, I merely wish to direct attention to these, under the belief that they have been insufficiently prospected, and are likely to yield generously to such as are willing to go to the expense of bringing a sufficient supply of water on to the field and working them on an extensive scale.

ON THE GEOLOGY OF THE DISTRICT SURROUNDING WHANGAROA HARBOUR, MONGONUI COUNTY, AUCKLAND.

Report by Alexander McKay, F.G.S., Assistant Geologist.

Wellington, 5th November, 1890.

Introduction.

During April of the present year, in accordance with instructions, I made an examination of the geological features of the district surrounding Whangaroa Harbour, of the Kaeo Valley, and the country between Whangaroa and Mongonui. This work had for its object the ascertainment of the exact whereabouts and extent of coal deposits in the Kaeo Valley and at Mongonui, and also the extent and relations of the different members of the Cretaceo-tertiary and lower-greensand formations, which are largely developed in the district, and in which at various localities prospecting for coal has been carried on. Besides these matters of practical interest, my attention was also directed to the relation of the hydraulic limestone of the North of Auckland, with the view of determining what in this district are its relations to the beds that immediately underlie it, and to those that in sequence next overlie it; and, as a whole, to the acquirement of a more complete knowledge of the geology of the district.

Report.

That part of the North Auckland peninsula north-west of the Bay of Islands and Hokianga was visited and explored by the Director (Sir James Hector) during 1866, and again in 1872. The first of these examinations enabled the production of the first geological map of this part of the Auckland District,* which, as far the northern part of the peninsula is concerned, embodies almost the whole that is even now known respecting the geology of the northern part of the district. The results of the second examination are embodied in a report dated the 4th July, 1872 (Geol. Rep., 1871–72, p. 153). This deals specially with the coal-seams at Whangaroa and at Mongonui, and describes the trachyte agglomerate forming the bold headlands on both sides of the entrance to Whangaroa Harbour, and also the remarkable hills called respectively "St. Peter's" and "St. Paul's," the former on the north of the harbour opposite the Town of Whangaroa, and the latter on the south side, immediately at the back of the township. At places at or near the base of the trachyte agglomerate series are beds of "smooth-grained mudstone, containing fossil leaves of a very recent-looking character, comprising dicotyledonous plants and ferns, among the latter being a Pteris that closely resembles

* Geological Sketch-map of Northern District of Auckland Province, by James Hector, F.G.S., Sept., 1866. Scale, 4 miles to 1in. Printed by W. C. Wilson, Lithographer, Auckland.

the common bracken still growing on the hills" (*l.c.*). The coal-formation surrounding the upper part of the harbour is next described, and the rocks of the lower part of Kaeo valley are referred to as forming the upper part of the coal-formation, and supposed to be the equivalent of the coal-formation at Kawakawa and Whangarei (*l.c.*, p. 154). With reference to the discovery of a coal-seam of value in the Upper Kaeo valley, the report continues thus: "Subsequently to my visit a thick seam of coal was found, associated with green sandstone, in the upper part of this [the Kaeo] valley, but I am not aware of the precise locality." Next follows a description of this coal, and a comparison of its quality with the coals of Greymouth and Kawakawa. Following this, the coal is described in general terms as "a non-caking coal, and in this respect, and in the rather large percentage of water it contains, it resembles common brown coal. It yields half its weight of bright, glistening coke, with a fair amount of gas, but rather less in quantity and of a feebler illuminating power than the Kawakawa coal, to which, however, it is superior in respect to the small quantity of sulphur it contains" (*l.c.*, p. 154).

During the season of 1874–76 the Whangaroa district was again visited by the Director of the Geological Survey, and in the Progress Report for that year this is referred to as follows: "A few days were devoted to the re-examination of the coal-bearing strata exposed in the district. The general structure of the country has already been described (Geol. Rep., 1872, p. 153), and the only additional point discovered was the existence at Kaeo River of the greensands, with the characteristic fossils of the covering beds of the coal at Kawakawa and elsewhere, and that these are separated from the underlying Inoceramus beds of the Amuri series by beds of quartzose grit."—(Progr. Rep., 1874–76, p. iv.)

In June, 1875, I was sent to Whangaroa "to trace the outcrop of coal in the Kaeo valley, and to discover its relations with the Mesozoic strata which occur there, and to connect it with the coalfield which is worked at Kawakawa, Bay of Islands." At this time I examined the rocks at Cape Horn and near Mr. Bell's on the north side of the harbour. At Cape Horn I saw but few or no indications of the presence of a coal-seam; and near Bell's, where prospecting by boring had been carried on almost within high-water mark, although traces of coal had been found, the prospects of a workable seam were not of an encouraging nature. No regular seam of any kind was exposed in the natural sections that could be studied, and, although a few inches of coal had been cut in the bore, this of itself was not sufficient to warrant the works being proceeded with. The strata being inclined to the horizon at considerable angles made it evident that any coal which was or might be cut in the bore, if continuous, must show on the surface at no great distance, and, as there was no evidence of this, I had to report unfavourably on the prospects of finding coal at this place also.

With respect to the coal in the Upper Kaeo, I was not more successful in finding a workable seam. I was accompanied to the Upper Kaeo by Mr. Bell, who collected the original sample forwarded to Wellington in 1872. The excavation made by Mr. Bell had fallen in, and nothing or little could be seen. It was clear, however, that no seam of coal had been found, but only scattered pieces in loose *débris* and slope-deposits, which consist mainly of brown and green sandstone.

The lumps of coal occur in a black clay, and close to the underlying Secondary rock. At the outcrop this black clay was very thin, and only small pieces of coal were found; but, on being wrought into, the thickness of the coal increased to 20in., the pieces being larger and the quantity greater; but the furthest point reached showed no signs of a solid roof.

The locality surrounding the slip was carefully searched for the coal *in sitû*, but without success.—(Geol. Rep., 1874–76, p. 57.)

Subsequently, in 1885, I made further search to discover and ascertain the true position of this coal; and, it having been reported that a prospector named Fyfe had discovered seams of coal at Kerikeri, Takau Bay, and on the height of land near to where the road from Kerikeri to Whangaroa first overlooks the Kaeo valley, I engaged Mr. Fyfe to guide me to the various outcrops known to him. At Kerikeri, under the falls of the river, he showed me a bed of clay and tufa under a thick sheet of volcanic rock, in which were numerous carbonised plant-remains, but no other or better indications of a coal-seam. This I had previously examined while in the district in 1883–84, and on this occasion was more than ever convinced that no coal of good quality was likely to occur in the beds under the Kerikeri Falls. At Takau Bay the prospects were even more hopeless.—(See Geol. Rep., 1883–84, p. 44.)

I next went to the Upper Kaeo, being assured of the existence of a good workable seam exposed in the banks of a ravine situate within Murray's Bush, and, by the description given, quite close to the slip in which I had previously found pieces of coal when I visited the district in 1875. However, the seam proved far too thin to work, and the quality of the coal at its best was very inferior; and, although I could not identify the place as being exactly that I had previously examined, it was clear that this was the same coal, as the same dark clays and soft greenish tufaceous sandstone were associated with and overlay the coal, while both above and underneath the coal occurred hard grey volcanic rocks, proving clearly that this coal had no connection with the Cretaceo-tertiary beds of the vicinity on which the lowest volcanic rocks rest unconformably.

The first sample sent from the locality being a coal of fair quality, while that obtained later from the outcrop in Murray's Bush being very inferior, there was still some uncertainty as to whether the first and last samples had been obtained from outcrops of the same seam in the near vicinity of each other. To clear up this doubt, accompanied by Mr. Bell, who first found coal at this place, I again visited the locality, and this visit placed the matter beyond all doubt that this coal is not of Cretaceo-tertiary age, but occurs at the base of the great series of volcanic breccias that cover a large part of the northern district of Auckland.

The volcanic rocks which cover the whole country between Kerikeri and the Upper Kaeo extend to the north between the Kaeo valley and the coast-line, and form an elevated table-land called the Tridac Plain. On the slopes from this to the coast-line, and into the Kaeo valley, Palæozoic rocks of Carboniferous or Devonian age are exposed. Near Kaeo Township these rocks carry reefs of white quartz similar in character and appearance to the silver-bearing reefs of Puhipuhi. Samples of these were collected and subsequently analysed in the Colonial Laboratory, but yielded no metallic minerals other than iron-pyrites. Reefs of this quartz appear on both sides of the Kaeo valley, the rocks in which they occur extending west between the north branch of the Kaeo River and the Pupuki, falling into the upper part of Whangaroa Harbour.

Along the upper part of both these streams the gravel in their beds are largely composed of crystalline diorites, which are developed in the range dividing the watersheds of the two streams. These crystalline rocks extend west along the northern part of the Hokianga watershed, and are strongly developed in Maunga-taniwha Mountain.

The Cretaceo-tertiary rocks that are exposed along the banks of the Waitangi, between Waimate and Black Bridge, though for the most part obscured by overlying volcanic rocks, extend north across the Kerikeri watershed, and are well exposed along the upper part of the south branch of the Kaeo River. In the valley of the north branch of the Kaeo, near Messrs. Shepherd's farms, these Cretaceo-tertiary rocks are well exposed, the hydraulic limestone here forming the highest member of the series. Below this are soft sandstones, in which calcareous concretions are imbedded. The sandstones contain Inoceramus, and the concretions a variety of marine shells. These are in the same horizon as the fossiliferous beds in the Upper Waitangi, and in the east branch of the Waihou River, from which collections of Cretaceous fossils were obtained in 1888 (Geol. Rep., 1887–88, pp. 46, 50). On this occasion, in the Kaeo valley four or five species of ammonites were collected, besides a variety of other fossil shells common to the other localities mentioned.

The brown sandstones of the Lower Kaeo are also present in this north branch of the Kaeo, and contain the characteristic fossil of that formation. As shown in section the extent of the brown sandstone is limited, the range to the north being formed of sandstones and diorites of Palæozoic age, while to the east and south all the higher grounds are covered by volcanic rocks of Tertiary date.

Further down the Kaeo valley hydraulic limestones, as an outlier of small extent, appear in the road-cuttings within half a mile of Kaeo Township. These to the eastward are overlain by volcanic rocks, which are well seen on the abrupt slope leading on to the Tridac Plain. Within the township, and for a short distance along the road leading to Whangaroa, Palæozoic rocks cut by quartz-reefs are exposed. Beyond the bridge leading across the river to the Pupuki, and the north side of Whangaroa Harbour, heavy beds of rubbly, shelly limestones belonging to the same series, and probably underlying the green and brown sandstones of the Lower Kaeo, form high cliffs overlooking the road-line. These are separated by a wide swampy tract from the hydraulic limestones and green and brown sandstones forming the hills between Hayes's Landing and farm and the mouth of the Kaeo River.

At Hayes's Landing isolated masses of hydraulic limestone show in the road-cuttings at the north end of the bridge, which here crosses a tidal and sluggish tributary of the river. More to the east the same rocks are seen *in situ*, underlain by sandstones and dark-coloured shales.

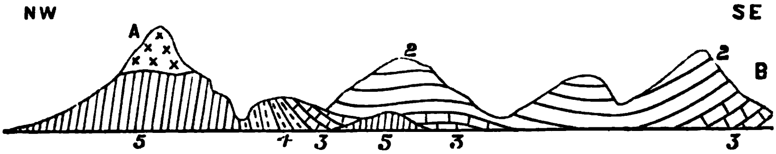
To the north the green and brown sandstones of the Lower Kaeo overlie these rocks, and, so far as can be determined, do so conformably; but in this part no clear sections are to be found.

The green and brown sandstones are well exposed along the road-cuttings between Hayes's farm and the mouth of the Kaeo River, and continue along the south-east shore of the harbour to the southern side of the valley, at the back of St. Paul's Range. In the intermediate space—*i.e.*, between Hayes's and the south-east side of St. Paul's Range—the green and brown sandstones of the Lower Kaeo are seen at several places resting on the higher beds of the hydraulic limestone with apparent conformity, and at one place, on the shores of the harbour, they are seen to rest on the older rocks of Palæozoic age. These green and brown sandstones from the Lower Kaeo strike east between St. Paul's Range and the northern edge of the Tridac Plain to the dividing-ridge separating the creeks draining into the Kaeo from those falling into the eastern part of Whangaroa Harbour, or to the sea-coast outside the entrance to the harbour.

On the west side of the Kaeo valley, from opposite Hayes's to the mouth of the river, the green and brown sandstones form hills similar in appearance to those on the east side, but in this direction the formation scarcely extends beyond the road-line leading from Kaeo to Totara and the north side of the harbour. On this side of the river the green and brown sandstones, wherever their lowest beds are seen, rest on the higher beds of the Cretaceo-tertiary series as developed in this district—to wit, the hydraulic limestone or the flint and firestone beds usually underlying, but which I suspect are at places the equivalents of, the hydraulic limestones.

These Kaeo greensands have hitherto been regarded as belonging to the Cretaceo-tertiary and coal-bearing series of the north district of Auckland, and place has been assigned them as being lower in the sequence than the hydraulic limestone, and as being the equivalents of the greensands over the coal at Kawakawa.

In the following section they are shown as overlying the hydraulic limestone, and this relative position of these green and brown sands is also shown by the section at Shepherd's, in the north branch of the Kaeo :—



Section from Whangaroa Harbour through St. Paul's along the east side of Kaeo valley to Hayes's. A. St. Paul's. B. Hayes's, in Kaeo valley. 1. Volcanic breccias forming the higher part of St. Paul's. 2. Kaeo green and brown sandstone. 3. Hydraulic limestone and firestones. 4. Sandstones and shales with traces of coal. 5. Palæozoic rocks.

Neither here nor in the north branch of the Kaeo is it quite clear whether the green and brown sandstones overlie the hydraulic limestones conformably. The evidence in favour of this assumption is that the green and brown sandstones, when in contact with Cretaceo-tertiary rock, always rest on the highest beds of the calcareous division of that series; and, beside the two localities mentioned as showing this, the same thing is seen on the west side of the Lower Kaeo on the road from Kaeo Township to the north side of Whangaroa Harbour.

In the section just given the green and brown sands are shown resting on Palæozoic rocks, which may be considered as an evidence of unconformity between these sandstones and the higher beds of the Cretaceo-tertiary series in the same section; but this is not necessarily the case, since the sandstones may merely overlap the hydraulic limestones, and thus, without their intervention, rest on the older rocks.

The fossil contents of the Kaeo sandstones are of a Tertiary character, and, of the several species found in them, few or none are found in the fossiliferous strata that underlie the hydraulic limestone. This must undoubtedly be regarded as strong evidence of unconformity. But, on the other hand, it has to be admitted that at Pahi, in the Kaipara district of the northern part of Auckland, fossils of quite as Tertiary an aspect are found in the greensands that underlie the hydraulic limestone; and the same thing happens both at Whangarei and at Kawakawa, and thus the palæontological evidence in favour of unconformity is rendered of little importance.

There remains, however, the important fact that the Kaeo sandstones stratigraphically overlie the hydraulic limestones, and thus are not the equivalents of the greensands over the coal at Kawakawa and Whangarei, nor yet the equivalents of the greensands at Pahi.

The only rocks in the northern district of Auckland to the horizons of which they might reasonably be referred are—first, the Tertiary beds that on the west coast south of Hokianga underlie the immense developments of volcanic material in the form of breccia-conglomerates in that quarter, and, second, the greensands following the hydraulic limestone in the Kawakawa section. These latter contain no fossils, so that by this means no correlation can be made, while in the first case the fossils from the Tertiary beds on the south side of Hokianga Heads are evidently of younger date than those found in the Kaeo sandstones.

As matters stand, it seems most reasonable to correlate these Kaeo sandstones with the greensands which in the Kawakawa section overlie the hydraulic limestone, which in previous reports I have referred to as the probable equivalents of the Weka Pass calcareous greensands typified in the northern part of the Canterbury District. Such an arrangement agrees best with both the stratigraphical and the palæontological evidence which may be gathered from a study of these rocks in the Kaeo valley.

The narrow belt of Cretaceo-tertiary or Young Secondary rocks at the back of St. Paul's as nearly vertical strata disappear in a westerly direction under the waters of Whangaroa Harbour. To the eastward the breadth of their exposure increases, and at the head of the first two arms of the harbour east of St. Paul's they reach to the water's edge.

In the valley of a moderate-sized stream that enters the sea outside and on the south side of the entrance to Whangaroa Harbour, the upper beds of the series are well developed, as fine-grained flaggy limestones underlain by siliceous firestones. In the upper part of the valley these rocks have an exposure of about two miles across, but towards the sea the hills are in their middle and higher parts formed of volcanic breccias, while along the shore-line Old Secondary or Palæozoic rocks are exposed.

There is little doubt that beneath the Kaeo sandstones these Secondary rocks to the east of the Kaeo valley are continuous with those that appear from beneath the Kaeo sandstones on the west side of the valley. These latter form the higher beds of the section exposed along the banks of the Pupuki River. Along the banks of the Pupuki the exposure of the lower part of the series is very clear and distinct. For four or five miles the river-banks show a succession of thin or thicker-bedded sandstones, alternating with dark shales. Concretionary boulders are met with in the higher part of the section (volcanic rocks along the lower course of the river obscure the firestones and hydraulic limestones). In following the river up, the base of the series was not reached, but from 1,000ft. to 1,500ft. of strata, all of the same character, was passed over in a distance of about four miles.

The dip of all these beds is easterly, towards the upper part of Whangaroa Harbour.

On the north side of the harbour, between the bridge over the Totara River and Cape Horn, these rocks dip at higher angles, and are not so regularly disposed as in the Pupuki Valley. The lowest beds of the section are well shown in the road-cutting west of the bridge. From the bridge east towards Mr. Bell's house and Cape Horn the shore of the harbour is covered with large concretionary cement boulders, and a little west of Bell's large masses of hydraulic limestone are seen; but lower beds again appear in the direction of Cape Horn, and thus it is clear that the arrangement of the beds in this section, between the Totara Bridge and Cape Horn, is as a syncline. Some years ago a collection of fossils was made from the concretionary boulders on this beach by Dr. Hector, and afterwards by myself; and subsequently, during the construction of the road from Totara Schoolhouse west to the bridge, a number of fossiliferous boulders were broken up, and some very fine fossils were thus obtained. Mr. Bell presented to the Auckland Museum a collection of the fossils thus obtained. This included some fine ammonites, and notably a large baculite in a fine state of preservation.

ON THE LIGNITES OF COOPER'S BEACH, MONGONUI, AUCKLAND.

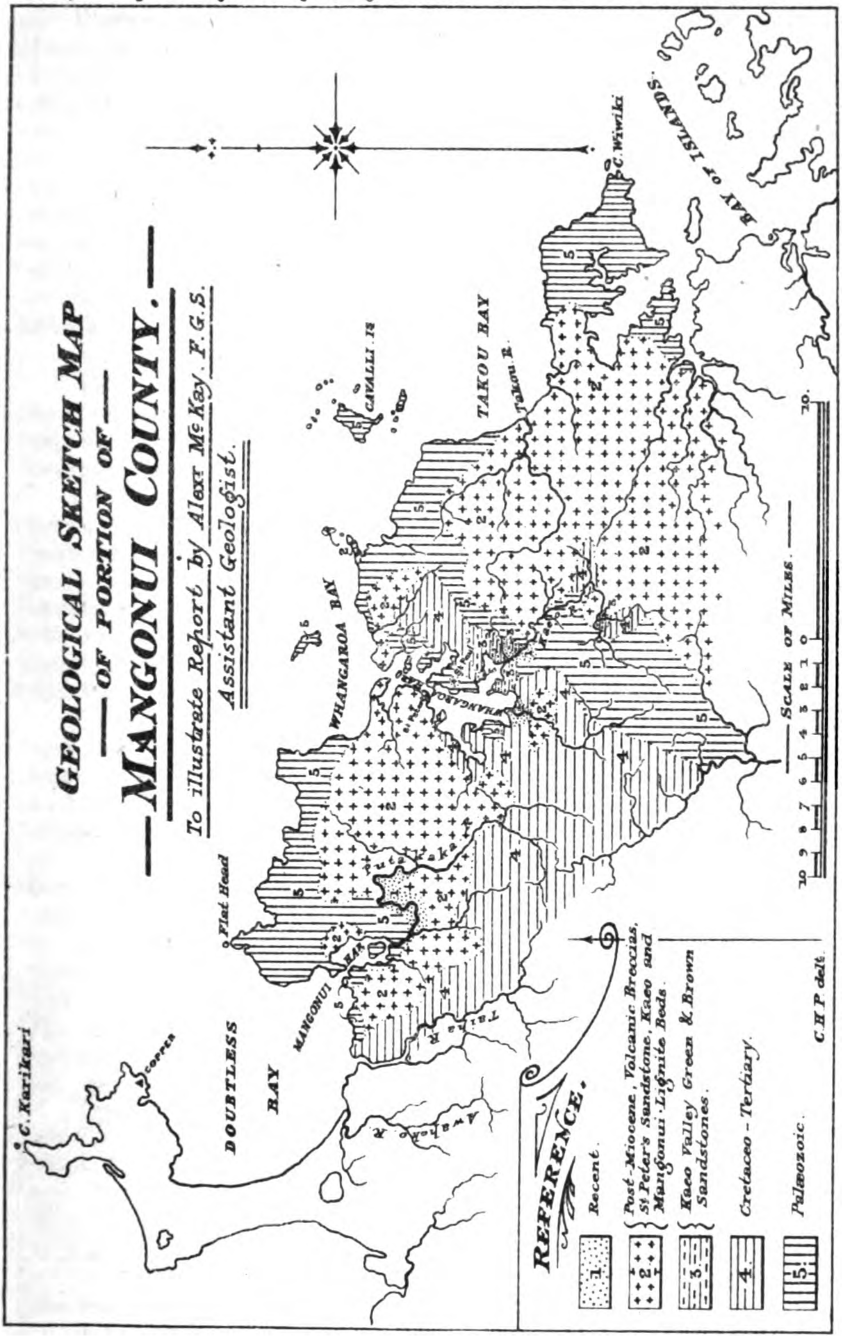
REPORT BY ALEXANDER McKAY, F.G.S., ASSISTANT GEOLOGIST.

Wellington, 5th November, 1890.

INTRODUCTION.

AT page 44 of "Coal Deposits of New Zealand"* Sir James Hector describes a sample of bituminous shale from Awatere, near Mongonui, Auckland. Only a small sample was sent to Wellington, and submitted to analysis in the Colonial Laboratory, the locality given being "on the authority of the Rev. R. Taylor. who discovered it many years ago. . . . . From the composition of this mineral [see page 46, 'Coal Deposits of New Zealand'], it will be seen that it approaches closely to the famous Torbane Hill oil-shale in character, to which it also bears a considerable external resemblance, with the exception of being rather darker and more resinous in lustre."

* First Report on the Coal Deposits of New Zealand, by James Hector, F.G.S., 1866.


GEOLOGICAL SKETCH MAP
OF PORTION OF
MANGONUI COUNTY.
To illustrate Report by Alexr McKay F.G.S.
Assistant Geologist.
C. Karikari
DOUBTLESS
BAY
MANGONUI
Flat Head
WHANGAROA BAY
CAVALLI IS
TAKOU BAY
Takou R.
C. Wiwiki
BAY OF ISLANDS
SCALE OF MILES
10 9 8 7 6 5 4 3 2 1 0
20
REFERENCE.
1 Recent.
2 Post-Miocene, Volcanic Breccias, St Peter's Sandstone, Kaeo and Mangonui Lignite Beds.
3 Kaeo Valley Green & Brown Sandstones.
4 Cretaceo - Tertiary.
5 Palæozoic.
C.H.P. delt.

During the first survey of the North Auckland district in 1866 by the Director of the Geological Survey, the locality indicated was examined without finding any further samples of this peculiar mineral; and while during the past season I was in the neighbouring district I was directed to examine the lignites of Cooper's Beach, near Mongonui, as it was just possible that the oil-bearing mineral might be found in or associated with these in the carbonaceous rocks at that place. I was also directed to examine the locality and beds whence come numerous examples of fossil fruits of a species of palm, and to determine the relation of the beds yielding these to the lignite formation of Cooper's Beach.

Report.

About the 20th April last I went from Whangaroa overland to Mongonui. One and a half miles north of the Totara River the Young Secondary or Cretaceo-tertiary rocks disappear under overlying deposits of a volcanic character.

On both sides of the entrance to Whangaroa Harbour the rocks are conglomeratic breccias, composed mainly of volcanic material. The denudation of this material gives rise to an extent of exceedingly rough country on the coast-line north of the entrance to the harbour. Farther to the west the range skirting the north side of the harbour is composed of this material, which continues west till the range terminates north of the bridge over the Totara River.

Towards the sea-coast the breccia conglomerates of this range rest directly on the older Palæozoic rocks that fringe the coast-line; but from St. Peter's Mount, directly opposite St. Paul's and the Township of Whangaroa, soft tufaceous sandstone and mudstones of a light-grey colour underlie the coarser material of the upper part of this formation, and rest partly on Palæozoic and partly on the Young Secondary rocks described in a previous report. These sandstones and mudstones do not appear to have any lignite-beds associated with them; but at places there is an abundance of fossil leaves of dicotyledons, ferns, &c. Passing to the north side of the range, following the road to Mongonui, the character of the lower beds under the coarse volcanic breccias changes considerably, and more resembles scoria ash, usually at the surface of a ferruginous colour.

This formation continues to within a mile of the river, along which the road leads to the upper part of Mongonui Harbour, when Palæozoic rocks begin, and continue along the low grounds and shore of the inner harbour to and beyond the Township of Mongonui. While the lower grounds thus show the presence of the older rocks, to the north and west at heights over 200ft. above sea-level the whole country is covered with or formed of the tufaceous beds which have already been mentioned.

A quarter of a mile before reaching the wharf and central part of the township a small creek discharges from the hills to the north into this part of the inner harbour. This drains mainly through Mr. Macintosh's farm, and to a height of 50ft. or 60ft above sea-level its channel is cut into the Palæozoic rocks, which are everywhere exposed along the shore of this part of the harbour. Following up the stream—a mere rill or absolutely dry in fine weather—above the heights mentioned, volcanic breccias of fine grain, associated with beds of clay, begin, and, with beds of a more sandy nature, these form all the hills to the north and west. About 50ft. from the base of the decomposing breccias there are, alternating with the breccias, beds of blue or whitish clay, and at this horizon both the breccias and the clays contain twigs and branches of trees, and occasionally tree-stems of small size. These do not form a compacted bed or stratum, but are singly imbedded and dispersed through the breccias and clay-beds. From this horizon it appears the fossil fruits are derived, but after a careful search I failed to find a single specimen *in situ*. It would appear that the fruits are imbedded in the clays and decomposed breccias, and so coated by tenaceous clay that it is only after they have been rolled along the bed of the stream and washed by the action of the sea-water at the mouth of the creek that they become recognisable. At all events it is from the beach at the mouth of this creek that most, if not all, of these fruits have been obtained. After heavy rains, when the creek by washing down its banks has become turbid, numbers of these fossils may be picked up on the beach at the mouth of the creek; and it is worthy of note that they are not found elsewhere than within a short distance of the mouth of this creek, and are often found imperfectly cleared of the clay in which they were originally imbedded, by which means they can be traced back to the deposits above described, and from which I have no doubt they are derived.

The banks of the creek being continually cut away by the action of the rains, causing slips and injury to the pasture-lands above, the proprietor, Mr. Macintosh, filled the narrower part of the water-channel with strong scrub, and dug down the steep banks on top of this, and by a second layer of this, and a further coating of clay material on top of that, hoped to arrest the cutting action of the stream during wet weather. This for a time had the desired effect, but the excessive rains during April last swept the channel to its original depth, and besides pulled down and carried away the clipped or solid banks, and with this result: that a large number of fossil fruits were collected on the beach after the flood had subsided. All the specimens collected appear to belong to one species.

A quarter of a mile to the north-east somewhat the same horizon of the breccias and clays are exposed at the back of the Mongonui Hotel, and here between the clay-bands a seam of impure lignite is exposed; but, so far, no fossil fruits have been found.

The same beds continuing to the north are well exposed in the high cliffs at the back of Cooper's Beach. The headlands at each end, east and west, of Cooper's Beach are formed of Palæozoic rock. Towards the east the lowest beds of the younger lignite-bearing series make their appearance as conglomerates and sub-angular gravels, derived for the most part from the older rocks of Palæozoic age. These beds alternate with and are followed by beds of sandy clay, and contain buried timber and wood changed to imperfect lignite or coal. The dip of the beds at this end of the beach is to the N.W. Concretionary kidney-shaped deposits of clay iron ore containing leaves are found in the higher beds of conglomerates. The leaves all seem to belong to species still existing in the neighbourhood.

The apparent dip beiug along the beach to the westward, the sandy clays following the conglomerates are succeeded by sands and blue clays, and yet higher by beds of white pipeclay. With these beds occur two or three seams of lignite, varying from 1ft. to 4ft. in thickness. The thickest and best seam, as regards its quality as a coal, is highest in the sequence, and this has been mined to some extent for the supply of local wants. But the seam in the face of the excavations had been allowed to get on fire, which ruined the workings, and since then no fresh openings have been made.

This, the principal and only important seam, is parted by a clay-band 2ft. thick; the upper part of the seam is 4ft., and that under the clay-band about 2ft. thick. On the exposed surfaces the lignite is of a black colour, but when broken into it is of a pale chocolate-brown and soft, and of an earthy character. Samples from the higher part of the seam were collected, and have since been analysed in the Colonial Laboratory, giving the following results:—

Fixed carbon	11·17
Hydrocarbon	33·18
Water	14·61
Ash	41·04
	100·00

Mr. Skey adds, "The above analysis shows that the shale as obtained is heavily waterlogged, but when dried has the constitution of a hydrous carbonaceous shale; whereas torbanite is anhydrous."

From the lower part of the seam samples were also collected, a specimen of which was also analysed, giving the following results:—

Fixed carbon	8·43
Hydrocarbon	25·50
Water	34·61
Ash	31·46
	100·00

Referring further to the first of these samples analysed, Mr. Skey says, "Judging the oil-producing powers of this shale by its composition, I should say—First, that, as the hydrocarbon is high as compared with the fixed carbon, the oil afforded by it would be of good quality; second, that, as the hydrocarbon it yields is 83·18 per cent. (as analysed), as against 70 per cent. in torbanite (yielding 120 gallons of crude oil), the yield of crude oil from the Mongonui shales would be nearly 58 gallons per ton."

It will thus be seen that the samples obtained by me from Cooper's Beach, though of fair quality as an oil-shale, are not equal to the original sample obtained by the Rev. R. Taylor, nor does it appear, from the description of the physical properties of the original specimen as given at page 45 of "Coal Deposits of New Zealand," that it could have come from the deposits examined on this occasion. Oil-shales of poor quality occur at different places in the Cretaceo-tertiary and Young Secondary rocks of the district, and I collected samples of such shales during my first visit to Whangaroa in 1875. Strongly heated, these shales would burn in an open fire, but the proportion of incombustible earthy matter was too great, the hydrocarbons present too little, to constitute this an oil-shale of any value. These samples were obtained near Shepherd's farm, in the north branch of the Kaeo River, and they point to the Cretaceous or Cretaceo-tertiary rocks west and north-west of Mongonui as the probable source of the Rev. R. Taylor's specimen.

ON THE NEW CARDIFF COAL PROPERTY, MOKIHINUI COALFIELD.

REPORT BY ALEXANDER McKAY, F.G.S., ASSISTANT GEOLOGIST.

Wellington, 8th April, 1891.

The Director of the Geological Survey.

SIR,—

In conformity with your instructions, I left Wellington on the 16th February, and reached the Mokihinui valley per steamer "Lawrence" on the 18th. There I was employed till the 10th March. On the 11th I went to Denniston, and thence reached Westport on the 13th. On the 15th I left Westport for Wellington, which I reached on the morning of the 17th March.

REPORT.

The area held or claimed by the New Cardiff Company occupies the central portion of the Mokihinui Coalfield, the Mokihinui Coal Company's lease lying to the eastward, while to the westward is the Patten's Creek lease.

The New Cardiff property extends along Chasm Creek for a distance of four miles from the junction of that creek with the

Mokihinui River, and is thus divided by Chasm Creek into two distinct areas, which will here be spoken of as the north-east and south-west areas respectively, as shown on the accompanying plan of the Mokihinui Block.

North-east Area.—The north-east area almost reaches the Mokihinui River at the junction of Chasm Creek, and the north-east boundary thence extends south-east (127° 30′) one mile, the county road along this part of the Mokihinui valley being the boundary. The boundary-line thence is carried south-west (227° 50′) a distance of 4561·8 links, and from that point south-east (150° 22′) 1250 links; and thence in a south-east direction (121° 28′) the distance is 3208·4 links. From this point, 2750 links from Coal Creek, this area on the south-east is bounded by the Mokihinui Company's lease till the latter reaches Chasm Creek, at a point 3370 links north of where Cooper's Line crosses Chasm Creek; and thence, to the Mokihinui River, Chasm Creek is the western boundary.

South-west Area.—The area west of Chasm Creek begins one mile from the junction of Chasm Creek with the Mokihinui; and its south-western boundary, separating it from the Patten's Creek lease and unoccupied country to the southwards, extends 21887·7 links to the northern boundary of that part of the Mokihinui Company's lease which lies westward of the upper part of Chasm Creek.

The greatest length of the north-east area is 17500 links, and the average width is 6000 links, while the average width of the south-west area does not exceed 4250 links.*

General Description of the Coal-bearing Areas between the Buller and Mokihinui Rivers.

The coalfield of the lower Mokihinui valley being connected with and forming part of a much larger coal-bearing area extending south and south-east to the Buller River, over all parts of which the rocks of the formation yielding the coal have been deposited under similar if not identical conditions, and have been subjected to movements disturbing the original position of the coal,—to show the general conditions of deposit, and the results of the movements indicated, it is necessary to give here a short description and history of the entire field.

Between the lower Mokihinui and Mount Rochfort Plateau, and from the low grounds along the coast-line to the Orikaka Valley, east of Mount William, coal and coal-bearing rocks occur at all elevations up to 3,500ft. From south to north along the central part of the field there is a gradual though not uniform descent of the floor of the field, from fully 3,000ft. on the Mount

* These measurements are taken from the map supplied by Messrs. Bayfeild and Co., Westport.

Rochfort Plateau to or below sea-level in the Mokihinui valley. In the cross-section from west to east there are at least two, and perhaps three, great longitudinal lines of fault, which divide the area into three sections:—

First. That which may be said to commence at the Ngakawau River, between Crane's Cliff and the sea, and thence extends between the foot of the coast-ranges and the shore-line to the Buller River, between the entrance to the Gorge and Westport. This is cut off from the central area by a great fault, extending along the coast-line to and beyond both the north and the south limits of the area under description, and is separated from the Mokihinui field by a range of crystalline metamorphic rocks between the lower Ngakawau and the first gorge of the Mokihinui River.

Second. That of the central area, embracing the coalfields of Mount Rochfort Plateau, Mount Frederick, and the Ngakawau valley, with the Mohikinui field farther to the north, and which is limited towards the east by a fault that in the south follows the valley of Cascade Creek, and runs along the base of Mount William Ridge to Cedar Creek, and thence probably extends north across the sources of the Ngakawau River to the eastern side of the Mokihinui field; in which latter part it is easily traced to the Mokihinui River at the foot of the second gorge, and further to the north along the base of the granite range on that side of the valley. From the heights of Mount Rochfort and Mount Frederick the coal-measures dip to the eastward into the lower grounds till this second line of fault is reached, beyond which the coal and coal-measures are found again at higher levels along the western side of the third area. North of the Ngakawau watershed the Mokihinui coalfield is bounded to the east and west by ranges of crystalline, granitic, or metamorphic rocks; and towards the north, on the west side of the field, there are distinct evidences of a heavy fault-line, which has not yet been traced southward into the Ngakawau watershed.

Third. The third section of the general field lies principally within the valley of Orikaka Creek, and includes also the coal of Mount William Ridge, the source of Cedar Creek, and the saddle between the Ngakawau River and Orikaka Creek.

The principal and most easterly part of this lies along the comparatively low grounds of Orikaka Creek, and between the sources of the Ngakawau and those of Chasm Creek, a tributary of the Mokihinui River.

The Mokihinui Field.—This lies north of the Ngakawau watershed, and between the coast and the first inland ranges before mentioned. South of the Mokihinui the greatest length of the field is about four miles, and the greatest breadth in an east-and-west direction is somewhat less, being about three miles and a half. This does not include what lies to the north of the Mokihinui River. Except immediately opposite the junction of Chasm

Creek no outcrop of coal is known on the north side of the Mokihinui valley. The higher beds of the coal-bearing series and the series succeeding, closed by the Cobden limestone, being developed in this direction, coal outcrops are not to be expected.

The coal-bearing area to the south of the river is divided into two parts by Chasm Creek. That to the east is embraced in the Mokihinui Coal Company's lease and part of the New Cardiff Company's ground. The area west of Chasm Creek includes the south-western part of the New Cardiff Company's ground, and west of that the Patten's Creek lease, together with some unoccupied country to the south and south-west.

East of Chasm Creek, the country north of Cooper's Track may be described as a table-land deeply cut into and divided by Chasm Creek from the country to the west; while towards the east and north-east it is broken by the valleys of several small streams draining into Coal Creek, or directly to the Mokihinui River itself. The average height of this table-land is between 400ft. and 500ft. On the west side of Chasm Creek the country in the central and northern parts rises to a greater elevation, and forms a range of hills, which, however, give place to lower ground to the south-west of Cooper's Track.

The New Cardiff Property lies on both sides of Chasm Creek. The north-eastern area, adjoining the Mokihinui Company's lease towards the south, and descending to the low grounds of the Mokihinui in its northern part, is the most accessible, and for the present certainly the most valuable, part of the property. That part which lies to the south-west and west of Chasm Creek is too difficult of access, or too distant from the present means of transit to the Port of Mokihinui or the Government line of railway being constructed, to insure profitable carriage by sea or by land to Westport.

The North-east Area.—Within this there are nine known outcrops of coal, which, on the plan accompanying, are numbered 1, 2, 3, 4, 5, 8, 10, 11, and 14. At No. 6 no coal-seam has yet been found, but rolled pieces of coal are found in the bed of the small streams feeding into Page's (not Chasm) Creek.*

The outcrops Nos. 1 and 4 dip between N. and N.N.W., and are evidently outcrops of the same seam. The thickness of coal in the latter case approaches to or exceeds 12ft. The dip is at a low angle, approximately 1 in 8 or 10, but, as in each case the seam has been driven on for only a short distance, this is to be determined as yet by the general lie of the country, and not from what can be ascertained at either of the outcrops.

No. 7 seam is supposed to be an isolated mass severed from

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* In previous reports Chasm Creek has been—erroneously, it seems—called Page's Creek. Page's Creek is the lesser stream lying to the east of the lower part of Chasm Creek, and falling into the Mokihinui close to the junction of Chasm Creek.

the general body of the coal by the fracture and sliding-forward (north) of the point of the spur between Page's and Chasm Creeks. I could not, however, satisfy myself that this is so, and, while admitting that the coal is much broken and slickensided, putting out of consideration faults which are not mere surface-slides, there is no evidence of this being separated, as indicated, from the extension of the seam to the south.

Outcrops Nos. 1, 3, and 5 seem to belong to an overlying seam of lesser thickness, never exceeding 4ft. No. 2 is exposed on the side of the road by the road-cutting merely, and has not been deemed of such importance as warranted its being further opened out. The dip here is to N. No. 3 shows about 4ft. of coal, dipping at a low angle to N.W.; while No. 5 shows not more than 1ft. of coal, dipping at a low angle apparently in a N.N.W. direction.

These five seams, or outcrops of one or two seams, indicate a limited area of coal lying between where they show and the east side of the lower part of Chasm Creek. Being convenient to the Mokihinui Company's railway-line, it may be possible to work this part of the area to profit; but it is apparent that not here will be the permanent and more remunerative operations of the company carried on. There is little doubt that the thicker seam showing at outcrops Nos. 1 and 4 are the same as the seam on the opposite or west side of Chasm Creek, which has been worked and abandoned by the Mokihinui Coal Company. There, in the rise working, the coal became too thin to work profitably; but this fact need not deter the opening-out of the same coal on the New Cardiff Company's property, since such thinning-out of the seam does not necessarily take place, and, indeed, from the position of the thick seam at No. 4 outcrop, it may be assumed that such thinning-out does not take place. The chief question for consideration is this: Is the extent of the area over which coal may be expected in this part of the company's property sufficient to warrant the bringing-in of proper means of conveyance, and the necessary costs of opening out on the coal in a proper manner?

Between the eastern outcrops marked and the line towards Chasm Creek along which the coal must inevitably appear at day, the average distance cannot be more than 15 chains, and may be less. The area of coal thus included would be about 50 acres, but the area actually workable would be considerably less.

At outcrop No. 8 there is a magnificent display of coal, as a thick seam, 18ft. to 20ft. thick. This dips E.S.E. at an angle of 1 in 10, and for some 6 or 8 chains the seam is clearly exposed in natural section.

The outcrop is 240ft. above the sea, and 110ft. above the bed of Chasm Creek immediately opposite the cut exposing the full

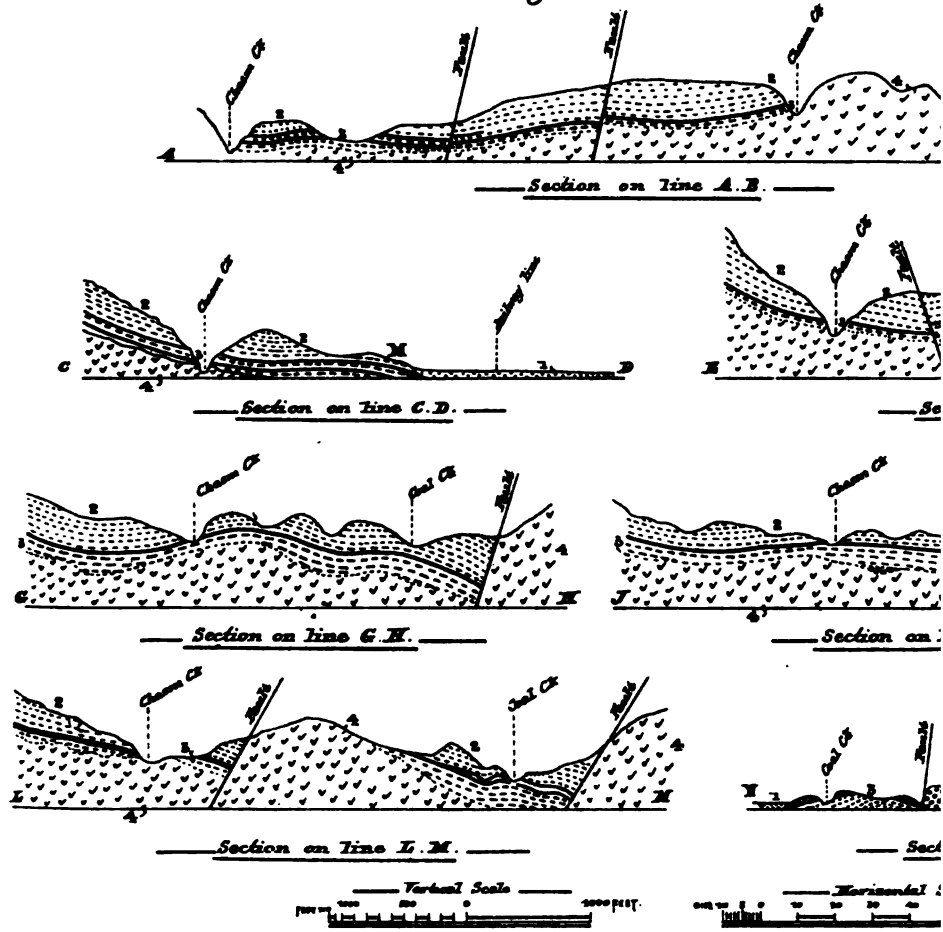
Geological Survey of New Zealand.

SIR JAMES HECTOR, F.R.S., DIRECTOR.

Geological Sections of the MOKIHINUI COAL FIELD.

To illustrate Report by A. McKay F.G.S. Assistant Geologist.

1.
2.
3.
4.



depth of the seam. For the last 60ft. metamorphic rocks resembling those showing at the wharf on the Mokihinui, and forming the lower gorge of the river, are exposed in the steep slope to the creek-bed. What rock underlies the immediate floor of the coal has not been ascertained, and it may be that the crystalline rocks are at a less depth than 50ft. below.

Although there is at this place convincing evidence of the value of this part of the company's property, the dip being to the eastward, only a small part of the seam in a northerly direction, towards the lower part of Chasm Creek, could be worked level-free, and to work the seam properly this should be sought for in the vicinity of the coal-outcrops indicated as occurring at or near No. 6.

As already stated, no seam has yet been found in that locality; and the dip of 1 in 10 from the Amy Hector or No. 8 outcrop would, if that dip be maintained, carry the coal to some distance below the surface at that place. But, if not this, then the thin upper seam is there exposed, and the distance to bore or sink for the main seam should not be great. In the neighbourhood of No. 6 is the most important locality of the whole of this area at which to discover coal, because of the high probability that the whole area to the west, east of Chasm Creek, would work to the rise of the horizon of the seam probably there to be discovered.

All the seams hitherto mentioned have a micaceous sandstone roof associated with beds of fine quartz-sandstone, and the approximate boundaries of this formation are indicated on the map accompanying this report. The remaining outcrops exposed within this north-east area of the property have grit for the roof of the seam or seams; but, as the two of these showing in the south-west part near the banks of Chasm Creek are also close down on the crystalline fundamental rocks, it is not held but that the micaceous sandstone and the quartz-grit may be the horizontal equivalents of each other, and this, too, in spite of the fact that in other parts of the field they can be seen vertically superimposed on each other, as, for instance, at the mouth of Chasm Creek, and in the tunnel and railway-cuttings of the Mokihinui Company's line.

No. 11, known as the Cave Seam, shows a fine face of coal. The actual thickness exceeds 12ft. or 15ft., but as yet the total thickness has not been determined. The dip is to E. at a higher angle than 1 in 10; but, as I had neither time nor means to determine this exactly, and the exposed roof being irregular, for the present the dip may be stated as approximately 1 in 8. The coal is exposed for a distance of about 2 chains under an overhanging roof of grit projecting some 15ft. beyond the upper part of the coal. The elevation of the outcrop is 430ft. above sea-level, and the height of land on the direct line to Coal Creek is about, or close on to, 700ft., and this, together with the dip of the coal, makes this like the outcrop of the Amy Hector, an unfavourable locality at which to commence mining operations.

Close to the southern boundary on this part of the property, on the east side of Chasm Creek, is outcrop No. 14, which may be designated Grant's Seam. This is 18ft. to 20ft. thick, and dips 1 in 10 E.S.E. The outcrop is 420ft. above the sea. The roof is of grit, while some beds of grit and dark shaly beds underlie the coal before reaching the crystalline rocks exposed at lower levels and along the bank of Chasm Creek. This is manifestly a continuation of the Cave Seam, and may be considered as occurring and behaving in almost every respect in the same way. The coal is of a tougher description, and in physical appearance more resembles a pitch-coal. Nevertheless it is bituminous, and has the peculiarity of affording on analysis the highest percentage of fixed carbon yielded by the whole series.

At the point marked by outcrop No. 10, during the progress of the examinations made for the purposes of this report, Mr. A. Grant discovered a 5ft. seam. This I did not see, as it was found by Mr. Grant under the following circumstances, and after I had visited the Cave Seam. Returning from the Cave Seam along the eastern boundary-line of the property, both on this and on a former occasion the conglomerates supposed to lie at the base of the series were observed at a height of 430ft. (see map), and we therefore speculated as to the near presence of an outcrop of coal in this vicinity.

Some search was made in the bed of a small stream flowing north-east to join Coal Creek, and fragments of bright, clear coal were found; but, the day being far advanced, and the bush dripping-wet from recent rains, the search was not prosecuted as otherwise it might have been. But a day or two afterwards, and before I left the district, Mr. Grant again went to the locality, and, following more to the eastward the indications met with, above the conglomerate and associated with the grit covering the whole of the table-land in this direction he discovered the outcrop marked, and which he ascertained to be at least 5ft. in thickness; the total thickness, under the circumstances, he could not ascertain. The height of this outcrop, therefore, somewhat exceeds 430ft., and thus outcrops Nos. 10, 11, and 14 are all at much the same elevation. Judging from the rocks observed along the boundary-line, the dip at No. 10 outcrop should be E. at a low angle; and there should thus be between this and outcrops Nos. 11 and 14 a synclinal arrangement of the rocks of the coal-bearing series. But, as may be observed by a reference to the map, there is a probability of the extension, through this part of the New Cardiff property, of a line of fault or disturbance showing on the banks of Coal Creek, and traced some distance in this direction by Sir

James Hector. It may be that this will account for the equal elevation of the outcrops at the three points, and at the same time show how this could be, the different dips considered. A second fault-line is undoubtedly present along the northern face of the line of cliffs, exposing the conglomerate and crystalline rocks at their base, and this, though mainly lying within the Mokihinui Company's lease, must be continued some distance into the New Cardiff Company's property, and, within that, affect the even distribution of the coal-seams. But, despite these probable facts, which are likely to cause some trouble in the future, it is evident that this southern portion of the area east of Chasm Creek cannot well be worked by beginning operations at any one of the known outcrops, but this should be done rather from the neighbourhood of No. 6, whence the whole of the central and southern parts of the property should be capable of being worked level-free.

It is needless to say more as to the importance of this locality, for, when it is remembered that, with the exception of No. 10 outcrop, the dips over the whole of this part of the field are to E. and E.S.E., a glance at the map will at once show the importance as well as the necessity of developing the field as here indicated.

South-west Area.—The northern part of this shows four outcrops of coal, Nos. 29, 9, 12, and 13, which, opposite or nearly opposite Nos. 8, 11, and 14 on the opposite bank of Chasm Creek, must be regarded as in every respect continuations of the same seam or seams, the severance being merely effected by the cutting down of the gorge of Chasm Creek.

None of these outcrops on the western bank of the creek was visited; but two of them—Nos. 9 and 13—are distinctly seen exposed by slips on the face of the range; and the other two—Nos. 12 and 29—had previously been visited by Mr. Grant, but owing to the swollen state of Chasm Creek could not be reached at the time the eastern outcrops were visited. Nos. 7 and 15 are outcrops marked in the plan supplied by Bayfeild and Co.; but neither of these was visited. In the case of the last-mentioned, I followed from Cooper's Track, west of Chasm Creek, a line running north in the direction of the outcrop; but, this not proving the west boundary-line of the property, we failed to find the coal.

The southern portion (south of Cooper's Line) of this south-west area has but one known outcrop of coal, situate about 40 chains above the point where Cooper's Line crosses Chasm Creek. The seam, 10ft. thick, shows in the left bank of the creek, and dips at a low angle to W.S.W. The roof of the coal is a dark micaceous sandstone, which is followed by the dark-grey or blue mudstone, or marly stratum, that forms the roof of the "Big Seam" in Coal Creek, and which covers almost the whole country west and south of the upper part of Coal Creek to and beyond Chasm Creek.

Within this part is the small area occupied by micaceous sandstone, containing the outcrop of coal already mentioned; and near the southern end of this there is a small exposure of crystalline schistose or gneissic rock, exposed only along the creek-bed and in its immediate banks.

South of Cooper's Line and west of Chasm Creek the area within the boundaries of this property may be considered coal-bearing throughout, with the exception of a small area of granitic or gneissic schist, extending about 10 chains up the stream from the crossing of the track (Cooper's Line). Where this disappears beneath the coal-formation dark shaly sandstone shows in the bed and banks of the stream; and coal is said to show in the bed of the creek, but, when an attempt was made to ascertain the correctness of this alleged fact, the flooded state of the creek prevented the truth from being ascertained, and no signs of coal could be discovered in the banks underneath the black shales there exposed.

There is within the New Cardiff property an area of about a hundred and fifty acres over which gneissic schist and other crystalline rocks appear at the surface, and within the north-east area towards the north-east boundary there are some two hundred acres covered by alluvia or terrace-gravels. There the coal, if present, must in this latter case be considered as below the line of level-free workings, or denuded away. In the extreme south part, as the dip at the one outcrop known is to S.W., it might seem that a large area in this direction would be below the water-level of the creek. This, however, is not the case, as the general dip of the strata along the banks of the creek is to E., and the W.S.W. dip noted at the coal-outcrop may be due to a fault seen at the boundary of the micaceous sandstone on the down-creek end of the area of these lower beds, associated with the coal.

The approach to the southern part of this property may be made by following the valley of Cascade Creek, from the end of the Mokihinui Company's railway, opposite the Hut Seam No. 20), to the saddle at its source, and thence the valley of another small creek, which joins Chasm Creek where this is crossed by Cooper's Line or track from Coal Creek to the upper Ngakawau. But it seems to be a likely matter that the development of this portion of the property lying to the west of Chasm Creek must follow that of the north-east area, within which there is plenty of scope for the energies of the company for years to come.

Coal.—Samples of coal were obtained from outcrops Nos. 3, 8, 11, and 14. These have been analysed in the Colonial Laboratory, with the following results:—

Analyses of Coal Specimens from the New Cardiff Company's Property, Mokihinui Coalfield.

Laboratory No. 5743 (4 specimens). Specimen (1), outcrop No. 11, Cave Seam; Specimen (2) outcrop No. 3, Big Seam; Specimen (3), outcrop No. 8, Amy Hector Seam; Specimen (4), outcrop No. 14, Grant's Seam.

	No. (1).	No. (2).	No. (3).	No. (4).
Fixed carbon	52·83	60·80	59·78	65·29
Hydro-carbon	40·01	30·58	33·18	27·87
Water	2·96	4·61	4·63	4·40
Ash	4·20	4·01	2·41	2·44
	100·00	100·00	100·00	100·00

Evaporative power, No. (1), 6·87lb.; No. (2), 7·90lb.; No. (3), 7·77lb.; No. (4), 8·58lb.

Notes by the Analyst on the Four Samples of Coal above Cited.—All are hard, compact, caking coals, homogeneous, and coarsely laminated. The coke of No. (1), the Cave Seam, is the most compact of the series; it is also the brightest. That of Nos. (2) and (3) is dull and somewhat loose, while that of No. 4 is the dullest and most incoherent of the lot. The ash of No. (1) is nearly white, that of Nos. (2) and (3) is of a pale-red colour, that of No. (4) being a deep red. This latter ash contains 72·22 per cent. of sesquioxide of iron,* equal to 1·75 of this compound upon the coal itself.

All these are excellent coals, and suitable—with the exception, perhaps, of No. (4), on account of its highly ferruginous ash—for use in ocean-going steamers.

In closing, I may note the curious fact that, although the coal from the Cave Seam—No. (1) of the series analysed by Mr. Skey—has almost no iron-oxide as a constituent of its ash, there is yet in near connection with the coal a very remarkable deposit of iron-oxide. I have already mentioned that the roof of the coal at the Cave Seam (a gritty sandstone) projects over the outcrop of the coal-seam some 15ft., thus forming the "cave." Under this shelter the gritty sandstones have a considerable thickness overhead, and from the surface water filtrates, and, carrying with it in a soluble form a portion of the iron contained in the grit-rock, this, at several places within the cave, drips on to the exposed surface of the coal. In this way has accumulated about a ton of pure hæmatite paint resting on the coal, and from this circumstance one might have supposed that the coal taken from this outcrop would be found more ferriferous than that of the other localities—Nos. 2, 3, and 4. But it may be here explained that the sample analysed was taken from a cut made into the coal at a short distanee from the hæmatite, and from about 4ft. from the original surface.

* The Coalbrookdale coal also has a large proportion of its ash composed of sesquioxide of iron.

ON THE MOKIHINUI COAL COMPANY'S PROPERTY, COAL CREEK, MOKIHINUI.

REPORT BY ALEXANDER McKAY, F.G.S., ASSISTANT GEOLOGIST.

Wellington, 11th April, 1891.

INTRODUCTION.

BETWEEN the 18th and 26th February last I examined that part of the Mokihinui Coalfield embracing the Mokihinui Coal Company's lease, which extends along the valley of Coal Creek and into that of the upper part of Chasm Creek. At the same time were made other examinations in the country to the west of the Mokihinui Coal Company's lease, which were of value in assisting to a right understanding of the sequence and disposition of the strata and coal-seams in the eastern part of the field; and, having made myself acquainted with the previous reports dealing with the Mokihinui Coalfield, I had thus my attention directed to several matters which might otherwise have eluded observation, and would not have been considered. Having been thus indebted to the reports of previous workers, in the following report for the purposes of description I shall avail myself of these to supplement my own knowledge, or for the purpose of describing localities I have not visited.

REPORT.

The Mokihinui Coalfield has been known as an area of great importance ever since 1866, when Sir James Hector, in the course of an overland trip from Nelson to Westport, passed from north-east to south-west along the more important parts of the field. During 1871–72 coal-mining was commenced at the point where the coal, showing in natural section, is exposed on the banks of Chasm Creek near its junction with the Mokihinui, and in the banks of the Mokihinui River itself. The then difficulties besetting the export of the coal by sea, and the smallness of the local trade, militated against the development of the field, and it was not till about 1884–85, on the formation of the Mokihinui Coal Company, that an effort was made to work the coal on a large scale. This company built a railway between the mouth of Chasm Creek and the position of the present wharf at the east end of the first gorge of the river, at which, the river being now tidal, sea-going vessels may be laden with coal. The same company commenced mining operations on the west side of Chasm Creek, in the near vicinity of the previous and original workings. Here the coal was favourably disposed for working, the rise of the floor being to the west and south-west, but on being followed in this direction it was found that the seam gradually thinned, and finally could not be worked with profit. To the north, in these workings, the seam also thinned, and in addition the presence of faults added to the difficulty of profitably working the mine.* In 1886 the company discontinued the working of this mine, and, having in the meantime prospected the principal outcrops of the seams along the valley of Coal Creek, they extended the railway-line to the 10ft. or Hut Seam in Coal Creek, and thence to the face of the 32ft. seam.

During 1886 Sir James Hector examined the various outcrops of coal showing along the banks of Coal Creek, and reported as to the extent and value of the area within the Coal Creek watershed over which coal might be worked level-free (Geol. Rep., 1886–87, pp. xliii. and 156). Since the date of that report to the present time the company have worked only at Coal Creek, and for the most part have been engaged on the 32ft. seam—the big seam.

The work done in connection with the two principal seams in Coal Creek, and such prospecting as has been effected since Sir James Hector examined the property, rendered it desirable that a further examination should be made, and I availed myself of these further facilities to examine the country towards the source of Coal Creek, and along the upper part of Chasm Creek, and along the boundary between this and the New Cardiff Company's property. The results are embodied in the description of the company's property which follows.

The Mokihinui Coal Company's Leasehold.—This in the north commences about 40 chains from the junction of Coal Creek with the Mokihinui River, and extends south along both sides of Coal Creek for a distance rather better than a mile and a half to where the eastern boundary crosses Coal Creek, and is continued across intervening spurs to and beyond Chasm Creek. From the south-eastern corner of the lease, the south-western boundary—from 25 to 30 chains distant—runs nearly parallel to Chasm Creek to the south-west angle of the New Cardiff Company's property, and thence follows the south and east boundaries of the New Cardiff property to the east-and-west line intersecting Coal Creek between the two railway bridges, this line forming the northern boundary of the lease. Of the area thus included from 80 to 100 acres shows granite or gneissic rock at the surface; denudation has also removed the coal from a small area along the lower levels of the valley of Coal Creek. The rest of the lease may be roughly considered as containing coal. Along the eastern boundary and thence to Coal Creek the greater part of the coal is below the drainage-level of the country. To the west the whole of the coal-bearing area is above the level of Coal Creek, with the exception of a small area on the down-throw side of the most southerly of the two faults marked on the accompanying map.

* For a description of this mine and its prospects, see Geol. Rep., 1886–87, pp. 161–167.

East of Coal Creek and south of its upper part to and beyond the upper part of Chasm Creek the rocks showing at the surface are the mudstones or marly beds with small concretions of ironstone, often highly calcareous. These beds in Chasm Creek are fossiliferous. They are underlain by soft micaceous sandstones and black shales, which often form the roof of the coal. These also are of marine origin, and contain a small species of Turritella, resembling that found in the roof of the coal at Whangarei, Auckland. The fossils from the overlying mudstone marls consist of Echinoderms and *Pecten zittelli*. From grits outcropping farther to the south Mr. Denniston collected a species of Cardium and a large oyster, *Ostrea carbonacea* (Hector, MS.). These grits, as the lowest coal-bearing beds, show under the Hut and Big Seams in Coal Creek, and on the western slope of the spur west of the Big Seam, on the road to Chasm Creek, but, as far as known, not elsewhere in the southern part of the lease. The grits cover the greater area of the north-western part. Towards the west they rest on gneissic rock, and to the north-east on a development of conglomerate interposed between the grits and the crystalline rocks here brought to the surface by the most northerly of the two faults shown on the plan accompanying.

The sequence of rocks present in this southern part of the Mokihinui Coalfield is thus, in descending order,—

1. Dark marly clays and mudstones, with beds of greensand at places south of Chasm Creek;
2. Micaceous sandstones and shales, with some beds of quartz-sandstone;
3. Grit and gritty sandstone;
4. Conglomerates, mainly formed of rolled boulders of quartz;
5. Schistose and gneissic rocks.

The coal-measures Nos. 1 to 4 have clearly this order of succession, but it is not clear that all the beds are present in particular sections, and Nos. 1, 2, and 3 may form the roof of coal indifferently. It is therefore difficult to determine the number of seams present in the field. The present workings on the Big Seam in Coal Creek show that this must be regarded as the highest, as the coal is almost directly followed by the dark marly clays, the first group of strata in the sequence given above. In this mine a shaft sunk into the floor of the coal cut a second seam of coal associated with micaceous and quartz sandstone, and this, without doubt, corresponds to the Hut Seam exposed on the right bank of the creek, 30 chains below the outcrop of the Big Seam.

Ten chains farther north another seam (?) is exposed in the cuttings of the railway-line. This is associated with gritty sandstones and thin beds of micaceous shales, and in this respect does not agree with either the Hut or the Big Seam. Again, on the high-levels north-west of the lower part of Cascade Creek, coal, associated with the grits immediately over the lower conglomerates, is found within the boundaries of the lease; and this is undoubtedly the same as the Cave and Grant's Seams on the New Cardiff property.

The coal showing on the right bank of the upper part of Chasm Creek (within the New Cardiff property, but undoubtedly also present in the Mokihinui Company's lease) has a roof of micaceous sandstone, and corresponds to the Hut Seam in Coal Creek, and to the Amy Hector and other seams in the north of the New Cardiff property. Several outcrops of coal on the left side of Coal Creek, above the Big Seam, seem to be outcrops of a continuation of the Big Seam in that direction.

Sections showing the Disposition of the Coal in various Parts of the Mokihinui Company's Lease.—The first in importance of these is undoubtedly that along the line J–K. This extends south-west from the north-east boundary, across Coal Creek and the intervening country, to and beyond Chasm Creek, to the south-west corner of the New Cardiff property, and intersects the outcrop of the Big Seam in Coal Creek, and the 10ft. seam on the left bank of Chasm Creek.

Towards the north-east the country is hilly, thickly covered with bush, and has been but little explored. The rocks at the surface are the marly beds and mudstones, generally dipping E. and N.E. East of the line the dip is reversed before reaching the foot of the granite mountains bounding the field in this direction, but this is not made apparent in this line of section. The small stream making junction with Coal Creek 6 chains below the Big Seam (marked 22 on the plan) was followed to the junction of the marly strata with the granite, and thence the country was crossed in a north direction, which led into the bed of the next creek to the north, which joins Coal Creek a little above the seam marked 19. The coal at the outcrop of the Hut Seam (marked 20) dips to E., and, dipping in this direction, has been driven on a distance of 600ft., at which distance the dip showed indications of changing to an easterly dip. This change of the dip is clearly seen in the banks of the creek joining Coal Creek below the Big Seam; and more to the east, in the upper part of Coal Creek itself, the dip is seen to change again to E., which dip is retained to the junction of the coal-measures with the granite.

The easterly dip is not sufficient to bring the coal to the surface, and in none of the creeks on this side of the valley of Coal Creek are any traces of the micaceous sandstone or grits of the lower measures to be met with, so that north of the Big Seam the greater part of the coal must be regarded as being below the water-level of Coal Creek north of the Big Seam.

The coal outcrop No. 18 shows in the face of a rocky cliff on the east bank of Coal Creek. The dip at this place is to N., and this shows that in the line of section (J–K) the coal must eventually rise; but whether along the line of section this is due to the synclinal arrangement of the beds, or to the influence of the most northerly of the two faults shown on the plan, has not been determined.

Between the Hut Seam (No. 20) and the Big Seam (No. 22) the most southerly of the two faults crosses the valley of Coal Creek, but, on account of the sameness of the strata over the coal, and the thick covering of bush on the hill-slopes, this cannot be traced at the surface. The disturbance thus caused is clearly seen in the bed of Coal Creek on the line of section N–O, in detailing which a further description of both faults will be given.

On the west side of Coal Creek the line of section crosses the outcrop of the Big Seam, 32ft. thick. From the exposed face at the north entrance to the mine the floor of the coal rises to the south at an angle of 1 in 10. This gradual and regular rise is probably interrupted by the steep dip to S. shown in the section. This exists in the most westerly workings of the mine, and is met with in all the headings on the west side of the anticline, which runs south-south-west from the Big Seam in Coal Creek to the outcrop of the schistose rocks in Chasm Creek above Cooper's Line. Beyond the sudden dip, as shown in sections J–K and L–M, the coal resumes its ordinary grade, and to the west of the anticline and section-line, due to the steep slope of the hills towards Coal Creek, is exposed at the three outcrops marked Nos. 24, 25, and 26.

The extension of this and the underlying Hut Seam* over the intervening country to the locality of the outcrop in the upper part of Chasm Creek cannot be doubted, and, not regarding local dips of greater amount, the rise of the coal between the two points is an average of 1 in 15. The height of the Big Seam in Coal Creek is 230ft. above the sea, and that of the 10ft. seam in Chasm Creek is 540ft. above the wharf at the end of the railway-line, or 570ft. above the sea, which, in a distance of a little over a mile, admits of an average rise of the coal as above stated.

This rise of the floor, on which the coal rests, affects the line above which the coal will be found level-free in the workings on the Big Seam, as these are pushed to the south-south-east along the course of the upper part of Coal Creek, and this line will be divergent to the eastward from the parallel of the anticlinal ridge, and as the workings on this side of the anticline progress southwards it is probable that the coal in the deepest part of the syncline, indicated and already alluded to as present along the upper part of Coal Creek, will prove to be more than 250ft. above the sea, and to be capable of being drained by a simple extension of the present workings on the Big Seam.

In like manner, to the westward of the anticline and line of

* Mr. Straw, the company's manager, reports that in the latest workings it is seen that the Hut and Big Seams come together on the west side of the sharp dip or syncline, as shown in section L–M illustrating this report.

section the rise of the floor would tend to widen the area of coal which could be worked level-free. However, owing to another cause (see section L–M), the area on this side—that is, below the water-line—is very limited, and lies to the north-west and north of the outcrop of the Big Seam.

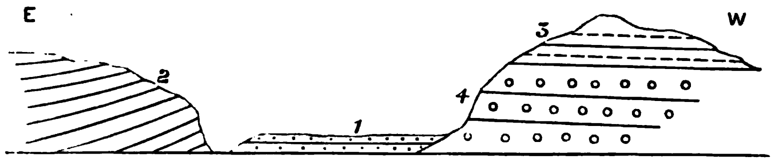
Section G–H is a cross-section of the southern part of the company's lease. This from the west boundary of the New Cardiff Company's property runs east-north-east, and crosses the outcrop of the 10ft. seam in Chasm Creek, and in the same line is continued to the upper part of Coal Creek, where its bed is 475ft. above the wharf. It will be seen, by comparing the position of the coal in this with the position of the outcrop in Coal Creek in sections J–K and L–M, that almost all the coal along this line is above the level of the mine-workings on the Big Seam.

Section L–M, east of the central granitic outcrop, is drawn also across the outcrop of the Big Seam in Coal Creek, and shows the breadth of coal level-free in this direction to be about 30 chains. This widens in the south to about 50 chains along the line G–H.

Section N–O runs parallel with the mean direction of Coal Creek from the first railway bridge to the upper part of the creek near where section G–H crosses the creek. The coal-strata and coal showing in the cliffs exposing the seam numbered 18 dip to N., and the coal here is overlain by micaceous sandstone, followed by mudstones and marly strata. Beneath the coal, coarse quartz-sandstones are exposed, dipping in the same direction. Above the second bridge the dip of these later beds changes to a south direction.

A seam of coal of irregular thickness is exposed in one of the railway-cuttings. This was 5ft. to 7ft. thick where first exposed, but on being followed to the north-west, along the steep slope on that side of the creek, it rapidly thinned out. This coal, much crushed, is overlain by coarse sandstones and thin beds of micaceous shale or sandstone, as seen in the southern end of the railway-cutting exposing the coal-seam. The beds that follow are not clearly exposed, the alluvial deposits of the creek hiding these from view.

The next rock seen is the conglomerate forming the lowest beds of the coal-bearing series. Between this and the gritty sandstone covering the coal last mentioned (outcrop No. 19) there is unmistakable evidence of a fault, having a down-throw on its north side of not less than 200ft. The clear and unmistakable evidences of this lie further to the north-west along the line traced on the map, where at the base of a steep cliff the granite is exposed. On this rests the conglomerate, and this in the higher part of the cliff is followed by grits and coarse sandstone with coal (outcrop No. 17). The line drawn on the map shows the average direction of the fault; the actual fracture probably follows more closely the line of cliffs indicating its presence. This terminates on Coal Creek nearly opposite the Hut Seam, and very probably the fault is continued to the east for some distance beyond Coal Creek; but, as the rocks in this direction embrace a considerable thickness of the mudstones and marls forming the upper part of the coal-bearing series, and no steep scarp now indicates the presence of the fracture, there are no means of tracing it further in this direction. That it is so continued is evident from the arrangement of the rocks along a line east-and-west across Coal Creek, 5 chains below the Hut Seam, as shown in the following section:—



1. Alluvial. 2. Shales over Hut Seam. 3. Sandstone. 4. Conglomerate.

The gritty and micaceous sandstones under and overlying the Hut Seam, together with the coarse grits that underlie, are at least obscured on and almost of necessity absent from the east side of the conglomerates, and in the banks of Coal Creek are exposed the mudstones and marly beds that cover and follow the Big Seam. Ten chains higher up the creek than the outcrop of the Hut Seam an outcrop of coal (No. 21) shows on the left bank of the creek. This is crushed and much disturbed on account of the near presence of the second line of fault in the Coal Creek area. This crosses the creek at or a little above the point where the tramway-line crosses to reach the mouth of the mine on the Big Seam, and has the effect shown in section N–O.

The synclinal arrangement of the coal and coal-measures shown in the further part of this section, from the Big Seam along the upper part of Coal Creek, as shown, agrees with the strikes and dips observed during an exploration of the upper part of the creek.

When Sir James Hector examined this part of the field in 1887, he determined the existence of the fault crossing the creek between the outcrop of the Big Seam and that marked 21, and described it as follows: "There is evidence of only one important dislocation of strata—at the point marked E, where there is an east-and-west fault with a down-throw to the south, which brings the brown-shale formation for a distance of 10 chains on to the south-west side of the creek; and this throwing-back of the coal more deeply under the solid ground in that direction is, if anything, favourable for facilitating mining operations. The amount of the throw of the fault cannot be ascertained until it has been exposed either by driving or sinking, but it probably does not exceed 60ft. or 70ft."—(Geol. Rep., 1886–87, p. 157.)

At the time the report above quoted from was written the country to the north-west between the lower part of Coal Creek and Chasm Creek had not been explored, and the appearance of the conglomerate along the left bank of Coal Creek below the Hut Seam was considered as being due to an anticlinal arrangement of the strata in that direction.

As shown in section N–O, the strata on the north side, carrying the coal-seam, dip to S., so as to apparently pass under the conglomerates; but this could not be seen at the time of Sir James Hector's visit, and the existence of this second fault was not suspected. Further to the north-west on this northern line of fault the beds dip away from the line of fracture, and in this direction it consequently becomes an anticlinal fault, while the southern line, as far as it has been traced or its presence inferred, seems to retain the character of a synclinal fault.

Extent of Coal within the Mokihinui Coal Company's Lease.—In dealing with this question, Sir James Hector says: "Owing to the denudation by the creek, the outcrop of coal follows a line on the south side of the creek, irregular both in altitude and direction. The rise of the coal to S.W. is about 1 in 12, while the rise of the slope of the hill" (at the Big Seam) "is about 1 in 5, so that in a short distance the coal-seams gain a very fair and solid covering. . . . As only one fault, and that having an east-and-west direction, has been observed in a distance of 20 chains, the coal may be reasonably expected to occur throughout the high ground lying between Coal Creek and Page's (Chasm) Creek, where it has been found to crop out. Making a rough estimate of the area denuded by the action of the creeks, and taking only the more solid parts of the country, it may be put down as only half a square mile, which is very moderate. The actual measurement is a strip north-east and south-west, 70 chains in length, and varying from 50 chains to 40 chains at the north end."—(Geol. Rep., 1886-88, p. 158.)

South of the most southerly of the two faults shown on the plan the area of coal-bearing country level-free between Coal Creek and Chasm Creek is as described and estimated in the above quotation from the report by Sir James Hector. To this, however, must be added the coal which lies level-free in the northerly part of the lease west of Coal Creek. The greater part of this has a considerable altitude (up to 650ft. above the sea), and all of it is above the level of Coal Creek, but there is no satisfactory evidence that thick and workable seams of coal occur in this part of the lease. It must, however, be said that this part has not been sufficiently explored, and it certainly should not be overlooked in estimating the area of workable coal level-free. There is also an area of undetermined extent on the right bank of Coal Creek, extending from outcrop No. 18 east through the hills in that direction. Where the coal is seen on the bank of the creek there are two thin seams of unworkable thickness; but further east these may thicken, or other and workable seams may be found. The measures extend east from the bank of the creek for fully half a mile, and dip at a low angle to N. The consequence is that most of the coal-bearing area north of the lesser creek, joining Coal Creek opposite to and a little above outcrop No. 19, is likely to be above the level of Coal Creek, between the two bridges on the railway-line. There is also a considerable area of the company's lease lying beyond the upper part of Chasm Creek, over which workable seams of coal may reasonably be expected to occur; but this, so far, has not been prospected, and in the meantime it is too distant from the means of transit to the Mokihinui Wharf, or of conveyance to Westport, where the Ngakawau–Mokihinui extension of the Government railway has been built.

Quality of the Coal. — During previous examinations many samples from Coal Creek have been collected and analysed in the Colonial Laboratory, and it was not deemed necessary to supplement these on the present occasion. Under this head Sir James Hector says: "Most of the coals cake strongly, and are of excellent quality both for household and steam purposes. The coal taken from the middle of the 32ft. (Big) seam proved to be one of the best steam-generating coals that have been found in New Zealand, as will be seen from the tabulated evaporative power. The coal from the supposed 10ft. seam (the Hut Seam) is, perhaps, of all the best suited for household purposes." The following table of analyses is taken from page 159 of the report of Sir James Hector:—

Seam.	Fixed Carbon.	Hydro-carbon.	Water.	Ash.	Evap. power.
Outcrop opposite to Hut	53·91	39·72	5·16	1·21	7·0
Tunnel-face opposite to Hut	58·34	32·38	8·51	0·77	7·6
Tunnel-face in 30ft. seam (Big Face) ..	64·32	27·70	6·01	1·97	8·3
Middle of outcrop	60·02	29·35	9·61	1·02	7·8
Outcrop 10 chains south of Big Face ..	59·02	31·60	8·57	0·81	7·6
Outcrop 5 chains south of Big Face ..	57·76	32·84	7·01	2·39	7·5
Coal from seam in fault	59·42	33·33	6·24	1·01	7·7

NOTE.—The ash is white or light-buff, and does not form a hard clinker.

"It appears from these analyses, therefore, that the coal from every point of the area examined is practically of the same quality, the variation in composition being quite within the ordinary limits from different parts of the seam in other places, and the best quality of all is possessed by the coal taken from the drive which has been made into the Big Face of the 32ft.-seam."—(Geol. Rep., 1886–87, pp. 158, 159.)

Remarks on the Hut Seam.—Since the district was last visited by Sir James Hector, the drive into the dip on the Hut Seam has been extended until it is now about 600ft. from where it enters on the right bank of Coal Creek. Throughout the whole length of the drive the dip continued to be to the eastward; but Mr. Straw, the company's mining-manager, informed me that at the further end of the drive there are indications of a change of dip to the westward.

At the present time nothing is being done in connection with this seam, and the tunnel could not be entered, being full of water. This work seems to have been discontinued on account of the difficulty, in comparison with the level-free workings of the Big Seam, of draining the mine. As the total dip did not amount to more than 60ft. or 70ft., beyond which there is evidence that the coal rises again, means for draining and working this mine should be taken, the more so as it affords a more coherent and harder coal than is at present being obtained from the Big Seam.

A considerable part of the 60ft. of dip could be got rid of by entering a water-adit 5 or 6 chains further north down Coal Creek, which would thus be placed 60ft. or 70ft. below the entrance to the Big Seam, and which, while draining the eastern part of the Hut Seam towards the outcrop, would enable workings, level-free, to be carried south in the direction of and under the Big Seam, and benefit that mine by extending the area which could thus be worked level-free in that mine also.

If it be as stated, that the bottom of the syncline was reached in the tunnel driven on the Hut Seam, the estimate of the area of workable coal within the valley of Coal Creek should be increased by a breadth of 12 or 15 chains. This is easily shown.

The rise to the south of the floor on which the coal-measures rest would soon enable the deepest part of the Hut Seam to be drained level-free (if a water-adit were driven as above indicated); and beyond this even a greater breadth of coal could be worked to the rise on the eastern side of the syncline. It is true that the disturbance due to the presence of the southern fault would have to be considered, and, perhaps, the expected results discounted to some extent, but the down-throw on the south side of this is probably not greater than was estimated by Sir James Hector, and there is a possibility of its even being less. Admitting the down-throw to be the amount stated, it means nothing more than that a further portion of the synclinal trough would have to be left unworked, or drained by other means than the adit-level hinted at.

Remarks on the Big Seam.—At present this seam only is being worked for coal. The principal entrance to the mine is on the north side of the hill in which the outcrops of this seam are seen. The main drive runs north-and-south, and from the eastern outcrop 4 chains further up Coal Creek a cross-drive has also been made. These and the other workings of the mine show that under the hill terminating the spur from the higher range to the west the arrangement of the strata and coal is as an anticline, the axis of which runs north to south, and at the same time is raised towards the south. This has already been shown in the description of section J–K. The east-and-west drive, after passing the anticlinal axis, follows the floor of the coal, and is driven, with a dip to the west, a distance of 6 chains. The drive to the dip grades about 1 in 10, but the coal dips at a greater angle, and at the west end the top of the drive is nearly into the roof of the coal. Towards the end of the drive the coal dips 1 in 6, and finally plunges at a high angle, which had not been determined when I visited the mine.

At the 225ft. level a drive was being driven north, which was intended to reach the surface 2 or 3 chains to the north of the principal entrance to the mine, thus draining the mine to the level of the main entrance, 25ft. having been lost through the southerly rise of the floor and the main drive running along the east side of the anticline.

The trough formed by the sudden and high dip of the coal at the end of the east-and-west drive must be narrow, as shortly beyond the point reached underground the measures on the surface dip regularly and at low angles towards E. (see section L–M), and I should recommend the carrying forward of the east-and-west drive, leaving the coal in the dip of the syncline, in order to gain the seam at the level-free line on the rise of the coal on the west side of the trough.

The coal near to and in the trough of the syncline is somewhat tender, and yields only small coal. On the crest of the anticline it is, and on the west side of the syncline it should be, of a harder description, affording coal more suited to the requirements of the general consumer.

I understand that since the date of my visit the east-and-west drive has been discontinued, and also the drive following on the water-line to the north, and that work is now being carried on in the southern headings on the west side of the anticline. This change of workings in the present interests of the company may have been advisable, but it is to be regretted that at the same time the east-and-west drive is not being pushed forward, as there can be no doubt that a large area of easily-worked coal lies beyond the sudden dip, and forms the west side of the synclinal trough.

The two properties which have just been described comprise the more accessible, and at the present time the most valuable, part of the Mokihinui Coalfield. To the west of the New Cardiff property is the Patten's Creek lease. Over this coal-seams are known to crop out, and to the south and south-east of these three properties there is a large area as yet unoccupied, over which it is certain seams of great value will be found, the produce of which must also be conveyed to market by way of the Mokihinui valley.

Sufficient has here and elsewhere been written to make clear the great value of the Mokihinui Coalfield, and it is needless to add more under this head in this place. The field has been slow of development solely on account of the want of facilities for bringing the coal to market. For, though the Mokihinui Coal Company displayed great energy and spared no expense in the building of a railway-line to the Big Seam in Coal Creek, the building of a wharf and coal-bins at the shipping place, and the clearing away of obstructions in the river-channel, yet on account of the uncertain state of the bar, regular and certain despatch of cargoes by sea cannot be made; and the recent loss of the Company's steamship "Lawrence" shows that not until there is railway connection with the Port of Westport is the field likely to be developed as it should be. As the contracts for building the line to connect the company's with the present terminus of the Government line at Ngakawau have been let, and are being proceeded with, in the near future this desirable state of things will be accomplished, and from that hour the real progress and prosperity of the Mokihinui District will begin.

ON THE GEOLOGY OF THE MIDDLE WAIPARA AND WEKA PASS DISTRICTS, NORTH CANTERBURY.

Note by Alexander McKay, F.G.S., Assistant Geologist.

Wellington, 1st May, 1891.

Introduction.

Last January I went to the Weka Pass and Waipara districts, for the purpose of examining afresh some of the more important sections along Weka Creek and its tributaries, and in the Middle Waipara.

Report.

Weka Pass District.—The stratigraphy of the Cretaceo-tertiary and Tertiary beds in and on both sides of the Weka Pass is so definitely clear and simple that it is surprising this should have afforded the subject of discussion that has taken place on this question. The great point requiring settlement is the position of an unconformity supposed to be present, and almost necessarily present, between the base of the Waipara series (Cretaceo-tertiary) and the highest beds of the Pareora series (Miocene). These evidences, it will be inferred, must be feeble and inconclusive, since the unconformity is differently placed by almost every geologist who has visited the district; and, in one instance, the existence of any unconformity has been denied altogether. Von Haast placed the unconformity and the upper limits of the Waipara formation at the junction between the Grey Marls and the Weka Pass calcareous greensand; Professor Hutton places it between the Weka Pass calcareous greensand and the underlying Amuri limestone. Sir James Hector places it between the Grey Marls and the lower beds of the Mount Donald sequence, equal to the Mount Brown beds. Mr. Park says that no unconformity whatsoever exists or can be detected from the base of the Waipara series to the uppermost beds of the Pareora series. I agree with Sir James Hector, and place an unconformity between the Grey Marls and the overlying Tertiary beds belonging to the Mount Brown series. The evidence in support of the views held by each of these observers it is not my purpose to detail in this place, as I contented myself with photographing a few of the critical exposures relied on; and from Pass House went to the Middle Waipara, following the track on the northern side of the Dean's Range.

Middle Waipara.—On my arrival at the Waipara I commenced work at the lower end of the Doctor's Gorge, where the lower beds of the Waipara series are seen resting on the slates and sandstones of Triassic age, which have been excavated to form the Doctor's Gorge of the Waipara River. The lowest beds, here seen resting at a low angle on the older rocks, are sands and sandy shales containing small nests of bright, and a thin seam of impure, brown coal. These strata, dipping E., are closely overlain by the black-oyster bed exposed *in situ* on the southern or left bank of the river. Large masses of the shell-bed have fallen from the outcrop in the face of the cliff, and protect its base against the encroachment of the river. From these fallen masses a number of fossils in a good state of preservation were obtained. These included the black oyster common to the lower beds of the Amuri series at Amuri Bluff, also common to the Amuri series, *Conchothyra parasitica*, McCoy, MS.; *Trigonia sulcata*, Hector; *Cucullæa alta* (?); and, common to the Waipara and the Malvern Hills, *Venus selwynensis*, Hector, MS., at which place and in the Trelissick Basin also this particular form of Ostrea and Conchothyra, the former very abundantly, is found. The dark colour of this oyster, it is not claimed, constitutes a specific character, yet it is peculiar that wherever found, unless blanched by exposure to the weather, it is always of a black colour. This colouring of oyster-shells is not unknown in the younger Tertiary beds of New Zealand, but is not a constant characteristic, as in the case of the Waipara and the Malvern Hills. The other shells collected at this place were in a much more fragmentary state, and some of them yet require examination to determine the genera to which they belong. Notable among these is a species of Cardium, which, so far as yet ascertained, is peculiar to this horizon and to the Waipara as a locality.

In the section down the Waipara grey quartz-sands follow the oyster-beds, until about 100ft. from the commencement of the series saurian boulders make their appearance on both banks of the river, but principally on the opposite left bank, on which side, the lower part of the section being obscured, the black-oyster bed is not seen. The sands in which the saurian concretions occur, pass downwards into the sharp quartz-sands of a grey colour that overlie the black-oyster bed, but upward they soon become dark from the presence of glauconite, and earthy from the admixture of argillaceous matter, finally they become or are succeeded by clays of a dark, or when dry, of a light, grey colour. From the base of the section to the top of these clay-beds there is shown about 400ft. of strata.

The saurian concretions arranged, here and elsewhere, in lines along the face of the cliffs, indicate the dip of the beds at low angles to the E. or E.N.E. They are often encased in 5in. to 6in. of impure cone-in-cone limestone, or by an envelope of similar thickness composed of sandy calcareous matter, preserving fucoid stems so abundantly that these must have formed a perfect envelope round the nucleus and greater mass of the concretion. Interior to this cone-in-cone or fucoidal covering, the concretion is a hard greyish-blue limestone rock, and the remains of various species of saurians when present for the most part appear near the centre; but in cases in which considerable and connected portions of a saurian skeleton occur, the bones are sometimes found through the whole diameter of the concretion proper, and into the cone-in-cone limestone or fucoidal envelope that surrounds the harder central portion. From the high cliff on the left bank of the river below the junction of Pirau Burn, concretions often fall into the channel of the river at its base, and in several cases, as at present can be seen, they leave imbedded in the marly greensands one-half or less of the cone-in-cone, more rarely of the fucoidal, envelope; also boulders may be seen *in sitû* from which one-half of the cone-in-cone envelope has been loosened and fallen off, leaving the concretion beneath perfectly round and smooth. When the calcareous matter accreting to form the boulder has from any cause been insufficient to include the whole of the remains within the concretion proper, some of the bones are fractured or jointed along the line joining the boulder and its envelope, and the bones thus appearing at the surface are polished as though the boulder had been formed mechanically, and transported to the position it now or lately occupied by the action of running water.

I have given this explanation at some length, because in the Geological Reports for 1870–71, page 6, Dr. Haast says: "I may here observe that the concretions with saurian remains are *in sitû*; consequently we cannot assume in any way that they have been washed from their original place of deposition to their present locality;" and again, on page 11 of the same report, he says "The organic remains are not always in or near the centre of the concretions but very often towards one or other side, or even close to the surface—an observation also made by Mr. Robert S. Holmes while collecting fossils from them for the Colonial Museum." Referring to the supposed transportation of the saurian boulders, in a foot-note on page 11 of the report above referred to, Dr. Hector says: "Mr. Holmes still adheres to his opinion, that the concretions containing the bones have been deposited in the sand-bed as rolled masses, as Dr. Haast offers no explanation of how the fragments of bone are exposed as water-worn surfaces on the exterior of the boulders." There can be no doubt that the explanation given above is the true one.

Concretionary boulders surrounded by an exterior layer of cone-in-cone limestone are found widely distributed over both Islands of New Zealand, from Moeraki in Otago to Mangonui in the northern district of Auckland. Along the east coast of the North Island, between Poverty Bay and East Cape, cone-in-cone limestone is often found adhering to and presenting the appearance of having grown on large fragments of Inoceramus shells. Very often when a concretion is not quite round, or is much flattened, the cone-in-cone is found only on the superior surface, and thins off towards the thinner sides of the concretion. In the bed of the creek opposite Hampden Railway-station, Moeraki, Otago, there is a very fine example of a concretionary boulder covered by cone-in-cone limestone. The layer of cone-in-cone, 4in. thick, separates freely from the smooth surface of the interior part of the boulder. In almost all the samples obtained from this boulder the cone-in-cone structure is perfect, and a large series of beautiful specimens of the cone-in-cone were collected. It is seldom in the Waipara that the cone-in-cone structure shows to such perfection.

I examined all the saurian boulders showing in the Waipara river-bed; but noticed only a few bones, and saw no indications of a connected series of bones in any of them. Nearly all the boulders that contain bones split in falling from the cliffs, or in being shifted along the river-bed, and it is never worth while to open a boulder so situated that does not show the presence of bones. Not being provided with the necessary tools, I made no attempt to open any of the larger concretions, and in searching for bones my object was the rediscovery of a portion of a boulder containing a large jaw of some saurian, which I had observed during my visit in 1871. For many years the shingle of the river-bed had covered the specimen up, and it could not be found. The last great flood again laid the specimen bare, and with some trouble I secured the specimen as part of the collection made during my last visit. It proved to be portions of the two lower jaws of *Leiodon haumuriensis*, Hector, extending about 15in. back from the muzzle. The bone was in a friable and decayed state where and near where exposed. The teeth, eighteen in number, were all finely preserved.

Some of the concretionary boulders contain shells, mostly in the condition of casts, but not unfrequently preserving the test also. Usually in the same shell-bearing boulder there is a mixture of monocotyledonous and dicotyledonous plant-remains. In a total of some 250 boulders examined, six or eight proved shell-bearing, and three were rich in shells. These were broken up, and most of the fossils in a recognisable state were collected.

It has been recognised by Sir Julius von Haast that the mollusca from the lower beds overlying the coal has, both in the Waipara and at the Malvern Hills, a decidedly Tertiary facies, and it was to be expected that the shells obtained from the saurian concretions belonging to a higher horizon would not be less of a Tertiary character. This is indeed true, not a few of the forms collected belonging to species obtained from the cover of the coal in South Canterbury and North-eastern Otago. One species, *Solenella sulcata* (Hutton), is common to the saurian concretions of the Waipara and the greensand over the coal at the Waihao Forks; while several forms common to these boulders and the shell-beds over the coal at the Waipara, in the Malvern Hills, and at Shag Point, clearly show that no confusion as to the age of the beds whence these boulders have been derived can arise. But on this head there are other and most conclusive evidence in the presence of *Belemnites australis*, Phillips, or that variety of this species described by Sir James Hector from the Amuri series at Amuri Bluff: *Trigonia sulcata, Apporhais*, and other species unquestionably cretaceous, and occurring most of them both above and below the Black Grit at Amuri. There cannot, therefore, be the least doubt of the equivalancy of the Waipara and Amuri Bluff beds, nor any doubt as to what age the lower part of the sequonce at each locality should be referred. Comparisons may now be made directly between the Waipara beds in the north of Canterbury and the coal-bearing beds of South Canterbury and North-eastern Otago, and if such lead to the conclusion that the formations are the same, then there can be no doubt as to the age of the coal strata in the southern localities.

I have elsewhere tried to show that the coal-strata of South Canterbury and North-eastern Otago are the same in age as the Waipara series in Northern Canterbury.

The dark clays, weathering to a grey colour, that form the highest beds in which concretionary boulders occur in the banks of the Waipara between the lower end of the Doctor's Gorge and the Limestone Gorge of the Waipara, are followed by greensands somewhat calcareous, and these form beds of irregular hardness in different parts, alternating with others in which the sands are looser, and the whole form very characteristic strata on both banks of the Waipara. Fossils are extremely rare in these beds, but in 1874 I collected from the loose greensands portions of ribs of *Pleiosaurus crassicostatus*; and Dr. Haast obtained from "these greensands *Waldheimia lenticularis*, of common occurrence in the Weka Pass beds"—*i.e.*, the calcareous greensands overlying the

Amuri limestone. Beds 5, 6, and 7 of Dr. Haast may be regarded as the greensand division of the series, the clay-beds, 6, not being always present. The higher and bright loose greensands are followed by grey argillaceous beds, best seen between the ford across the Waipara and the upper end of the Limestone Gorge. These pass upwards into light-grey marly beds, and indistinguishably into the Amuri limestone, as seen along the line of cliff on the north-west side of Ram Paddock, and at the upper end of the Limestone Gorge. The darker clay-marls at the base of this part of the series form large slips in the lower part of Birch Hollow Creek, joining the Waipara a short distance above the Limestone Gorge. Fish-teeth are the only fossils hitherto collected from these beds. They are of small size, and difficult to distinguish, being of the same colour as the clays in which they are imbedded.

The river being low, I was enabled to make a close examination of the junction line between the Amuri limestone and the overlying Weka Pass stone. The greensand, conglomerate, and parting-beds of greensand with phosphatic nodules, in the Weka Pass, are absent here; and, although the change from Amuri limestone to Weka Pass stone is somewhat sudden and sufficiently clearly marked, there is not in the cross-section exposed in the gorge or along the line of strike for a mile to the north-east or to the south-west, or elsewhere in this district, any sign of unconformity between these beds.

I took a number of photographs of the junction-line of the two limestones, and general views of the gorge, and of the whole line of limestone cliffs from the North Deans to the Waipara ford, all tending to show the stratigraphical conformity of the two limestones.

At the lower end of the Limestone Gorge, the Weka Pass stone is overlain by the Grey Marls. The section is clear and shows perfect conformity between the two. Below the Limestone Gorge I followed the river-bed to the junction of Bobbie's Creek, and photographed the junction between the lower part of the Mount Brown beds and the upper surface of the Grey Marls. A stratigraphical unconformity is here evident enough in the section displayed in the right bank of the river, and again a little further down on the left bank of the river.

The Mount Brown beds as displayed in the southern spur of the Deans Range, as in the Weka Pass, are formed of an upper and lower thick band of calcareous sands or shelly limestones, separated by from 100ft. to 150ft. of blue sandy beds containing shelly bands. The higher calcareous band forms a syncline on the north bank of the river, and on the southern bank the whole of the Mount Brown series forms a syncline from the outcrop of the Grey Marls, west of the Stone House, and north-west of the Natural Bridge, to the crest of the hill between the lower part of Bobbie's Creek and the northern slopes of Mount Brown.

On this line of section the syncline formed by the higher bed of limestone is well displayed on the east side of Bobby's Creek, the intermediate beds in the banks of the creek and the lower calcareous sands somewhat resembling the Weka Pass stone in the Ram Paddock, between the Stone House and the Natural Bridge. On the eastern side of the hill, between the lower part of Bobby's Creek and Mount Brown, the Weka Pass stone and Amuri limestone crops out, dipping to N.W., and the Weka Pass stone and following Grey Marls dipping E.S.E., finally pass under the lower beds of the Mount Brown series.

A line of fault runs north-westerly along the northern base of Mount Brown to Bobby's Creek, above the junction of Natural Bridge Creek, and brings the greensand below the Amuri limestone in contact with the different members of the Mount Brown series.

Concluding Remarks.

The discovery of *Leiodon haumuriensis, Belemnites australis,* and *Trigonia sulcata,* proving beyond doubt the identity of the Amuri and Waipara beds, must be considered as an important result of this visit to the Waipara. The observed stratigraphical relationship of the Amuri limestone to the Weka Pass stone is merely confirmatory of what had been amply determined before, which also may be said of the nature of the contact between the Grey Marls and the lower beds of the Mount Brown series. The Pareora beds are not developed within the area examined, and therefore the relation of these to the Mount Brown beds need not be discussed in this place. It is to be regretted that a thorough and systematic search of all the concretions exposed in the Waipara and its tributaries cannot be undertaken at the present time. The bed of the Waipara shifts frequently, and, as the case may be, buries or exposes bone-bearing boulders which, when opportunity is afforded, should be worked so as to secure the specimens they contain. As showing the importance of this, I may again mention the fact that the jaw of *Leiodon haumuriensis* lately obtained, although for nearly twenty years it has been known, has only recently been re-exposed above the shingle of the river-bed; and, again, the important evidence afforded by the boulder containing *Belemnites australis,* &c., had this not been secured at the time it was, might have been in the next flood buried up and practically lost for ever.

APPENDIX.

MINERALS OF NEW ZEALAND.

BY SIR JAMES HECTOR, K.C.M.G., F.R.S.

(Revised from Trans. Aust. Assoc. Sci., Vol. II., p. 269.)

[! Rare. !! Common. !!! In workable quantity.]

ACTINOLITE !—Milford Sound (Hector); Parapara (Cox), as radiating fan-shaped crystals in metamorphic schists.

ALBITE, or SODA FELSPAR ! !—Maori Point, West Coast, Wilkin River, Makarora, Dun Mountain, George Sound, in diorites (Hector, Haast, Davis).

ALUM ! !—Pomahaka, as a product of pyritous shale (Hector, 1862); Puai Island, Waikouaiti (Hochstetter, 1860); Tokomairirô, as potash alum (Hector, 1862); D'Urville Island, as manganese alum (Hackett, 1886). Analysis per cent. (Skey):—

Alumina	10·40
Ferric oxide	1·11
Lime	·50
Magnesia	5·46
Soda	·41
Sulphuric acid	37·40
Hydrochloric acid	Traces
Water	42·72
Insoluble in water	2·00
	100·00

ALUNITE !—Rotorua, deposited by geysers (Ulrich).

ALUNOGENE ! !—Tuapeka, Manawatu, occurring in some of the brown coals, is colourless, crystalline, and completely soluble in water. Analysis per cent. (Skey):—

Sulphate of alumina	55·60
Sulphate of lime	1·01
Sulphate of magnesia	2·99
Akaline sulphates	3·00
Water	37·40
	100·00

ANDESINE !—Colville Peninsula, Taupo district, Ruapehu, in andesites (Hutton).

ANORTHITE !—Kakapo Lake, West Coast, in diorite dykes (Hector). 1863.

ANTHOPHYLLITE !—Dun Mountain, Nelson, in a massive laminated form (Davis).

ANTIGORITE !—Dun Mountain, in serpentine schists (Cox).

ANTIMONIAL OCHRE !—Endeavour Inlet, as a coating on antimonite (Cox).

APATITE !—Wangapeka (Lab. and Geol. Reports).

APOPHYLLITE ! !—Turnagain Point, in amygdaloids, Rangitata, as Ichthyophthalmite in felsite porphyries (Haast).

ARAGONITE ! !—Collingwood, in caves; Dunedin and Thames in cavities in basaltic rocks and from hot springs, East Cape (Hector); and several other places, lining fissures and cavities in volcanic rocks of Banks Peninsula (Haast).

ARSENIC (NATIVE) !—Kapanga Mine, Coromandel, in auriferous quartz lode with calcite (Hector, 1864).

ASBESTOS ! ! !—Milford Sound, Collingwood, Takaka (Hector).

AUGITE ! !—Hororata district, Dunedin, Nelson, Auckland, Collingwood, Banks Peninsula, Acheron, Chathams; enters into the composition of all basalts, dolerites, augite-andesites, trachydolerites, diabases, and melaphyres; sometimes in crystals ½in. long, Nelson (Hector).

AWARUITE !—Gorge River, S.W. coast. In serpentine. Analysis (Skey):—

Nickel	67·63
Cobalt	·70
Iron	31·02
Sulphur	·22
Silica	·43
	100·00

AZURITE !—Nelson, Great Barrier Island, in gossan of copper lodes in serpentine.

BARYTES !—Waikouaiti (Mantell, 1852); Akiteo (Hector, 1867); Thames (Skey, 1870); East Cape (McKay, 1874).

BERYL !—Dusky Sound, in hornblendic schists (Cox); Stewart Island, with tinstone in large crystals (McKay), determined by Skey.

BISMUTH !—Owen River; Nelson, alloyed with gold (Hector), determined by Skey.

BITUMEN—Cast up on the south and east coasts of New Zealand in considerable quantity (Lab. Geol. Reports III.).

BOLE ! !—Lyttelton Tunnel, in dolerite rocks (Haast). Analysis (Skey):—

Silica	44.78
Alumina	15·66
Iron	16·87
Manganese	·60
Lime	2·02
Magnesia	5·02
Potash	2·69
Water (constitutional)	12·36
	100·00

BORNITE !—Kawarau; Dunstan, in micaceous quartz (Hector).
BOURNONITE !—Wangapeka, occurs in quartz with galena (Hector).
BRAUNITE ! !—Malvern Hills, vicinity of Wellington, massive (Geol. Survey, 1873).
BRONZITE !—Dun Mountain, in diorite rocks (Hector, Davis).
BROOKITE !—Otepopo, in crystalline dolerite (Hector, 1862).
CALAMINE !—Tararu Creek, as lustrous transparent crystals attached to diallogite, but always external (Skey).
CALCSPAR (CALCITE) ! !—Tokatea Range, Otago, in Tertiary rocks of Otago as Dogtooth spar; Nelson, in limestone caves; Canterbury, as Iceland spar (Haast, 1864); Dunedin, Seacliff, near Waikouaiti, Cape Rodney, Tararu Creek, Thames, as smoke-coloured calcite, Cape Rodney (Cox, 1882).

Marble ! !—Collingwood district (Hochstetter, 1860); West Coast Sounds (Hector, 1863); Kakahu, Canterbury (Monro, 1866).

Stalactite and *Stalagmite* ! !—Whangarei, Waipu, Collingwood, Mount Somers; occur in many limestone caves.

Travertine ! !—Oamaru, Mauriceville, Takaka, and many other places, deposited from calcareous waters (Hector).

CERVANTITE !—Widely distributed; occurs incrusting stibnite.
CHABASITE !—Dunedin, in vesicular basalts (Hector); Helenburn and Banks Peninsula, in trachytic rocks (Haast).
CHALCOPYRITE ! ! !—Kawau, Great Barrier Island, Moke Creek, Paringa River, Canterbury, Collingwood (Geol. Surv.).
CHIASTOLITE !—Collingwood, in clay-slate (Hector).
CHLORITE ! !—Fox Glacier, Westland, in chlorite-schists (Cox); Tararu Creek, Thames (Skey); West Coast of Otago and Otago Heads, in an amorphous form in vesicular basalts (Hector); Kakapo Lake (Liversidge).
CHROME OCHRE ! !—Nelson, occurs in combination with chromite in small quantities (Hackett, 1861).
CHROMITE ! ! — D'Urville Island, Dun Mountain, Aniseed Valley (Hochstetter); Red Mount, Otago, in a band of serpentine and olivine, also occurs as massive crystals, massive amorphous crystalline, disseminated, and granular (Hector, 1865): Nelson ! !, associated with nephrite (Hector, 1865). Sp. gr. 3·328. Analysis (Skey):—

Silica	12·66
Chromic oxide	47·69
Ferrous oxide	24·08
Alumina	6·29
Lime	3·16
Magnesia	6·12
	100·00

CHRYSOBERYL !—Stewart Island (determined by Skey, 1889).
CHRYSOCOLLA !—Nelson, incrusting gossans of copper ores in the serpentine belt.
CHRYSOTILE or PERIDOTE—Dun Mountain, traversing the dark-green serpentine (Cox).

CHLOROPHYLLITE !—Mount Somers, fine earthy mineral filling cavities in rocks (Haast).

COALS ! ! !—Special schedule, abstract of report by Sir J. Hector (Geol. Surv. Dept.).

COALS OF NEW ZEALAND.

No.	Description.	Locality.	Analysis by Skey.				
			Fixed Carbon.	Hydro-carbon.	Water.	Ash.	Evaporative Power.
1	Anthracite	Acheron, Canterbury	84·12	2·06	1·80	12·12	10·93
2	Bituminous	Coalbrookdale	74·83	20·50	1·16	3·51	10·72
3	,,	,,	70·00	22·15	2·52	5·33	9·10
4	,,	Banbury	69·97	25·71	·99	3·33	9·09
5	Altered brown coal	Malvern Hills	68·54	19·89	4·15	7·42	8.87
6	Bituminous	Tyneside	65·59	29·18	·82	4·41	8·52
7	Glance-coal	Rakaia Gorge	64·51	21·27	6·76	7·46	8·30
8	Bituminous	Wallsend	62·87	31·64	1·66	3·83	8·17
9	,,	Grey River	62·37	29·44	1·99	6·20	8·01
10	Pitch-coal	Kawakawa	61·16	28·00	2·51	8·33	7·95
11	Bituminous	Preservation Inlet	60·88	20·69	4·33	6·19	7·91
12	Pitch-coal	Black Creek, Grey River	60·20	29·97	8·01	1·82	7·82
13	Bituminous	Mokihinui	59·75	32·14	3·27	4·14	7·76
14	,,	Coalpit Heath	58·81	38·98	1·02	1·19	7·64
15	,,	Mokihinui	57·92	34·94	3·96	3·18	7·50
16	,,	Brunner Mine	56·62	35·68	1·59	6·11	7·36
17	,,	,,	56·21	37·83	1·50	4·56	7·30
18	,,	Westport	56·01	37·17	2·60	4·22	7·28
19	,,	Mokihinui	55·59	38·86	3·16	2·39	7·20
20	,,	Brunner..	54·16	35·85	2·50	7·49	7·04
21	Altered brown coal	Malvern Hills	53·29	32·04	12·65	2·02	6·92
22	Bituminous	Otamataura Creek	52·89	36·63	2·19	8·29	6·90
23	,,	Wallsend	53·10	35·47	1·41	10·02	6·90
24	,,	Near Cape Farewell	48·59	43·17	2·18	6·06	6·31
25	Pitch-coal	Shag Point	43·19	30·15	15·82	10·94	5·61
26	,,	Kawakawa	50·15	42·63	4·18	3·04	6·50
27	Glance-coal	Whangarei	50·11	38·68	8·01	3·20	6·50
28	Pitch-coal	Kamo	50·01	37·69	9·61	2·69	6·50
29	Brown coal	Malvern Hills	49·99	35·42	11·79	2·80	6·49
30	,,	Fernhill..	49·95	36·95	12·00	1·10	6·49
31	,,	Allandale	47·31	36·26	12·41	6·02	6·15
32	,,	Kaitangata	46·48	33·48	14·66	5·38	6·04
33	,,	Shag Point	46·21	32·65	16·02	5·12	6·00
34	,,	Homebush	44·92	36·00	15·83	3·25	5·83
35	,,	Hokonui	44·28	38·22	16·50	1·00	5·75
36	,,	Kaitangata	44·11	38·32	15·44	2·13	5·74
37	,,	Nightcaps	43·62	33·68	18·33	4·37	5·67
38	,,	Springfield	42·68	33·66	18·65	5·01	5·55
39	,,	Orepuki..	42·64	36·26	14·44	6·66	5·54
40	Pitch-coal	Walton's, Whangarei..	38·80	41·20	7·20	12·80	4·96
41	Brown coal	Kaitangata	38·29	32·43	17·50	11·78	3·87
42	,,	Shag Point	35·76	30·92	13·22	20·16	4·64
43	,,	Allandale	34·72	40·26	18·99	4·86	4·51
44	Pitch-coal	Grey River	34·72	55·48	6·20	2.60	4·51

Name of Coal.	Approximate Total Output of Coal up to the 31st December, 1888.
	Tons.
Bituminous	2,484,687
Pitch	803,948
Brown	1,797,725
Lignite	146,472
Totals	5,232,832

Total output of coals of New Zealand to 31st December, 1890, 6,454,758 tons.

COBALT BLOOM !—Otago, occurs in schists and gneiss (Hector).

COPPER (NATIVE)—Great Barrier Island, Nelson, Lake Wakatipu, Dun Mountain, Perseverance Mountain, &c., in plates associated with copper deposits in serpentine (Skey); as grains disseminated through a granular serpentine, Aniseed Valley (Hackett), and as fine grains in basaltic dykes which cut through trachydolerite breccias, Thames (Geol. Survey), (Cox).

Black Copper, or *Tenorite*—D'Urville Island.

Copper Glance !—Nelson, in various parts of the serpentine belts, in a massive form.

Peacock Copper—Maharahara, Champion Mine, occurs associated with native copper (Hector).

Red Copper !—D'Urville Island, Lake Te Anau; 35·60 per cent. copper.

COPPER PRYITES ! ! !—Waipori, Moke Creek, Coromandel, in a compact amorphous form (Hector). Analysis (Skey):—

Copper	15·03
Iron	28·00
Quartz	21·00
Sulphur	35·97
	100·00

COPPERAS !—Kawau, Barrier Islands, crystallized.

COVELLINE !—D'Urville Island (Hector, Cox).

DERMATIN !—Dun Mountain, West Coast Sounds, occurs in faces with smooth polished surfaces (Davis).

DIALLAGE, or ALUMINOUS AUGITE ! !—Kakapo Lake, in diorites and gabbros (Hector).

Green Diallage ! !—Mount Arthur, in serpentine schists (McKay).

DIALLOGITE ! !—Thames (Hector, 1881), associated with calamine; Makara (Skey, 1870); Paraparaumu, 1888, in a strong lode.

DILESSITE !—Mount Somers, fine earthy mineral filling up cavities in melaphyres (Haast).

DIOPTASE !—Thames, Nelson, occurs as an incrustation on the copper ores (Skey).

DOLOMITE !—Malvern Hills, interstratified with augitic sandstone (Haast, 1865); Collingwood (Hector, 1872).

DOPPLERITE !—Waiapu, formed as a surface deposit by oxidation of exuded petroleum (Hector, 1874). Analysis (Skey):—

Oils ...	3·1
Paraffin	9·3
Earthy matters	26·9
Water	11·3
Oxygenated hydro-carbons	49·4
	100·00

DUFRENOYSITE !—Great Barrier Island, as a fine crystalline vein associated with galena in large crystals (Hutton).

DUNITE ! !—Dun Mountain, found massive, named by Hochstetter, 1860. Analysis (Reuter):—

Silica	42·80
Magnesia	47·38
Protoxide of iron	9·40
Water	·57
	100·15

ELATERITE !—Kawau (Hector, 1865), hardness, 2; sp. gr., 1·034; Poverty Bay (Liversidge, 1877).

ELECTRUM ! ! !—Thames, usually found in places where gold occurs.

EMERALD !—Dusky Sound, in quartz with pyrrhotine (collected by Dockerty, determined by Cox and Skey).

EPIDOTE !—West coast of Otago, in granites (Hector); Mount Torlesse, in diorites (Haast); Wairarapa, in massive form (Hector). Analysis (Skey):—

Silica	44·71
Iron	14·66
Alumina	11·47
Lime	22·93
Magnesia	2·13
Water of constitution ...	4·10
	100·00

EPSOMITE, or EPSOM SALTS !—Otago, as an efflorescence (Hector, 1865).

FAYALITE !—Nelson, in schist, contains 2·6 per cent. copper (Skey).

FELSPAR (GLASSY) !—Taupo district, in rhyolites, &c. (Hector).

FLUOR SPAR ! ! !—Stewart Island and West Otago (McKay, 1889); Batton River, associated with sulphate of baryta (Park, 1889); determined by Skey.

FULLER'S EARTH !—Great Barrier Island Hot Springs, in trachyte tuffs (Hutton).

GAHNITE !—Stewart Island, with tinstone (McKay); determined by Skey, 1888.

GALENA !—Kaituna and Kaimanawa Range, associated with quartz, generally argentiferous; Wangapeka, containing an average yield of about 91oz. of silver per ton; Great Barrier Island (Skey).

GARNET (*Iron Lime*)—West Otago, in gneiss (Hector).

Black Garnet—Dunedin, in vesicular basalts (Hector).

GLAUBER SALTS !—Brancepeth, Whareama, Wellington, sample forwarded by Mr. W. H. Beetham in 1874 (determined by Skey).

GLAUCONITE !—Otago, occurs in schist and greensands as rounded grains in several of the younger Secondary beds (Hector).

GOLD (NATIVE) ! ! !—Auckland, Taranaki, Hawke's Bay, Wellington, Nelson, Marlborough, Canterbury, Otago, Southland, Westland; occurs plentifully in reefs, alluvial deposits, sea sand, &c., as crystals in the Ben Nevis Range and Mahakipawa.

GRAPHITE ! ! !—Pakawau, occurs chiefly as thin flat veins interstratified with metamorphic schist, was largely worked prior to 1866; and Mount Potts, and in the Glossopteris beds (Permian), (collected by McKay); a boulder of very pure graphite in a stream from Waikoura Creek, Mount Egmont. Analysis of Pakawau sample (Skey):—

Carbon	58·10
Water	2·68
Ash	39·22
	100·00

GREEN EARTH !—Malvern Hills, filling cavities in melaphyres (Haast).

HALLOYSITE ! !—Dunedin (Hector), in decomposing basalts; Water of Leith (Liversidge); Scinde Island (McKay). Analysis (Skey):—

Silica	58·22
Sesquioxide of iron	5·82
Alumina	24·34
Lime	2·02
Magnesia	2·53
Water	4·81
Alkalies and loss	2·26
	100·00

HAUERITE !—Wakatipu district, Collingwood, in crystals (McKay).

HAUSMANNITE !—Selwyn River, in rolled pieces and coating joints in rocks (Haast, 1865).

HECTORITE !—Dun Mountain, named by Cox, occurs with serpentine rocks (Cox, Trans. N.Z.I., 1882, p. 409). Analysis (Skey):—

Silica	59·89
Ferrous oxide	18·46
Alumina	4·74
Ferric oxide	Traces
Manganese	Traces
Lime	1·99
Magnesia	13·94
Water	2·98
	100·00

HÆMATITE !—Mount Gilbert, Nelson, Dunstan, as lenticular masses. Analysis (Skey):—

Silica	4·60
Alumina	3·00
Sesquioxide of iron	90·60
Water of constitution	1·80
	100·00

HEULANDITE !—Canterbury, in amygdaloidal traps associated with felsite porphyries (Haast).

HESSITE !—Te Aroha, in auriferous quartz (Hector); analysed by Skey.

HORNBLENDE ! !—Widely distributed (Hochstetter, 1859).

HYPERSTHENE ! !—Warp Point, Kotuku River, in diorite rocks and in hypersthenite (Hector).

IDOCRASE, or VESUVIANITE !—Dusky Sound, as dirty-green fluted prismatic crystals in quartz associated with crystalline rocks (Docherty), (identified by Skey).

IDRIALITE, or INFLAMMABLE CINNABAR !—Dunstan, Serpentine Valley, Waipori, Ohaeawai Springs, occurs as rounded grains in alluvium (Hector). Analysis (Skey):—

Water	6·89
Hydrocarbon	21·50
Cinnabar	34·10
Sand	37·51
	100·00

ILMENITE ! — Taranaki ! ! ! and in ironsands in all parts of New Zealand.

IRIDOSMINE !—Takaka, Orepuke, occurs in gold wash as small flat grains (Hochstetter).

IRON PYRITES ! !—Collingwood, Wakatipu district, &c., sometimes occurs in octahedral crystals (Lab. and Geol. Reports).

ISERINE ! !—Common on the West Coast, S.I. (Lab. and Geol. Reports).

JADE, NEPHRITE, or AXE-STONE ! ! — Milford Sound, Teremakau River, known as "Maori greenstone." It occurs as rolled pieces on the beach and as white nephrite (Hector). Analysis (Skey):—

Silica	51·03
Ferric oxide with traces of manganese and chromium	12·43
Alumina	1·42
Lime	9·00
Magnesia	21·35
Soda	Traces
Water (constitutional)	·97
	95·20

KAOLIN ! ! !—Manuherikia, Arrow River, Mount Somers, Collingwood, Stewart Island, formed by the decomposition of felsite porphyries (Hector, Cox).

KERMES !—Endeavour Inlet, occurs with stibnite.

KYANITE, or DISTHENE !—Westland, associated with quartz.

LABRADORITE ! !—Purakanui Range, Mount Charles, Banks Peninsula, in trachydolerites (Hector, Haast).

LEAD (NATIVE) !—Collingwood, in the wash of a creek in the form of round grains, like shot. It is alloyed with gold (Skey, Trans. N.Z.I., XII., p. 367).

LEPIDOLITE !—Thompson Sound, in marble (Hector).

LEPIDOMELANE !—Milford Sound, in schists and gneiss rock (Hector).

LEUCITE !—Castlepoint, in leucite basalt (McKay). Analysis of the basalt (Skey) :—

Silica	48·63	48·29	43·06
Lime	25·39	26·59	24·34
Alumina	20·70	20·47	11·47
Iron and manganese	Traces	Traces	7·24
Magnesia	2·93	·85	9·06
Water	2·35	2·53	3·42
Loss		1·27	1·41
	100·00	100·00	100·00

LEUCOPYRITE !—Thames, Reefton, Collingwood, with mispickel (Cox).

LIMONITE ! ! !—Whangarei, Parapara River, Shotover River, Collingwood, in massive earthy botryoidal, mammillary, and concretionary forms (Geol. Surv.).

MAGNESITE !—Rotorua, crystalline (Cox, 1878); Chatham Islands, massive (Smith).

MAGNETITE ! !—Lake Wakatipu, Mount Cook, disseminated through various rocks in minute crystals and grains (Haast), 72 per cent. iron (Skey).

MALACHITE—Moke Creek, D'Urville Island, occurs as thin encrusting films on some copper-ores (Hector, Cox). Analysis (Skey) :—

Copper	58·20
Iron	1·10
Silica	3·33
Sulphur	Traces
Carbonic acid and water	37·37
	100·00

MANGANITE ! !—Tory Channel, Kawaru, Clutha, Otago, Waiheke, Waimarama, Wellington, Waipu, "in veins in schists," "as rolled fragments in alluvial drift." Analysis (Skey) :—

Sesquioxide of manganese	63·42
Sesquioxide of iron	66·66
Alumina	Traces
Silica	7·25
Sulphur	Traces
Water (hygroscopic)	10·22
Water (constitutional)	12·45
	100·00

MAGARITE !—Milford Sound, in schists and gneiss (Hector).

MEERSCHAUM ! — Dun Mountain, in contact with massive white quartz (Davis). Analysis (Skey) :—

Silica	53·76
Lime	2·36
Alumina	4·35
Iron oxides	Traces
Magnesia	20·36
Water of constitution	19·17
	100·00

MELLITE ! — Bligh Sound, from a cave (Hector, 1863); Thames, described as a resinous substance with a splintery fracture (Hutton, 1870).

MENACCANITE ! — Brancepeth, Wairarapa, occurs associated with felspar (Skey).

MERCURY !—Waipori, Bay of Islands, Westport, occurs in alluvial wash in the form of small thin globules (Hector); contains 99·54 per cent. of mercury.

METEORITE, or METEORIC IRON ! — Wairarapa. Hardness 5-6, specific gravity 3·254, weight 9¼lb., contents 49 cubic inches; containing 24 per cent. iron, with silica, sulphur, nickel, &c.

MICA ! ! !—West Coast, in all schists; Charleston and Stewart Island, in granite as large plates.

(*Biaxial*, or *Potash*) !—West Otago, in schists (Hector).

(*Uniaxal*, or *Biotite*) ! — Dusky Inlet, Milford Sound, a black green mica rock with numerous minute crystals of zircon (Hector).

Chrome Mica ! — Dead Horse Gully and Dusky Sound, in flat tabular plates (McKay, Skey). Analysis (Skey 2) :—

Specimens from	1 Schwartzenstein.	2 Dead Horse Gully.
Silica	47·68	39·25
Alumina	15·15	22·12
Chromic oxide	5·90	1·56
Ferric oxide	5·72	18·69
Manganous oxide	1·05	·41
Magnesic oxide	11·58	10·60
Sodic oxide	1·17	1·13
Potassic oxide	7·27	
Water	2·86	4·06
Lime		2·18
	98·38	100·00

MUSCOVITE, or MICA ! !—Snowy Peak Range, Milford Sound, Charleston, Dusky Bay, Great Barrier Island, as a common constituent of mica-schist, gneiss, and granite.

MISPICKEL !—Milford Sound, Waipori, Malvern Hills, Collingwood, Thames, associated with gold (Hector, Hutton, Cox). Analysed by Skey.

MOLYBDENITE !—Dusky Sound, a flakes in a gneiss rock (Docherty, 1880).

NATROLITE !—Dunedin, in vescicular basalts (Hector); Banks Peninsula, in volcanic rocks (Haast); also in cavities of basalts from Dunedin (Hector); Mount Livingstone, Look-out Point, Whakahara.

OBSIDIAN, or VOLCANIC GLASS ! !—Mayor Island, Banks Peninsula, Mount Eden, Taupo Island, associated with rhyolites and on the sides of trachyte dykes (Hochstetter, Hector).

OLIGOCLASE !—Mount Misery, Malvern Hills, Snowy-peak Range, in quartz-porphyries (Haast, Daintree).

OLIVINE, or CHRYSOLITE ! !—Mandamus district, Hurunui district, in dolerites (Liversidge, Hutton); Banks Peninsula, Chatham Islands, as grains in basaltic rocks (Haast); Saddle Hill, Milford Sound, in basaltic rocks (Hector, 1862).

OPAL ! !—Mount Somers, Malvern Hills, inferior qualities only.

Common Opal and *Semi-opal* ! !—Malvern Hills, filling small cavities in quartz-porphyries (Cox, Haast).

Fire Opal !—Otago Peninsula, in tuffs, collected by Capt. Fraser, determined by Skey.

Opal Jasper ! !—Portobello, Otago, in trachytic tufa (Liversidge).

Pitch Opal ! !—Dunstan, Rakaia Gorge, Harper's Hill (Liversidge).

Wood Opal, or *Silicified Wood* ! !—Mount Somers, Canterbury, Coromandel, occurs in tuffs and conglomerates and where siliceous rocks are decomposing (Haast, Hochstetter).

Geyserite ! !—Rotorua (Hochstetter).

Hyalite !—Banks Peninsula, Malvern Hills, found lining cavities in volcanic rocks (Haast); Dunedin, in vescicular grey trachyte (Liversidge).

Menilite ! !—Bay of Islands.

ORTHOCLASE, or POTASH FELSPAR ! !—Mount Misery, Banks Peninsula, West Coast, Auckland Islands, Ruapuke, Great Barrier Island, Sugar Loaves, Boulder Bank, Nelson, Hororata district, Dusky Sound, as a constituent of granites, syenites, gneiss, trachytes, and rhyolites.

OZOKERITE !—Dunstan, Otago, occurring in brown coals (Hackett, 1865).

PALAGONITE ! !—Harper's Hill, Two Brothers, Taipo Hill, as angular fragments in palagonite tufas (Haast). Analysis (Skey):—

Silica	38·82
Alumina	23·17
Iron oxide	6·30
Lime	3·65
Magnesia	3·27
Alkalies	2·08
Water	22·76
Carbonaceous matter	Traces
	99·97

PEARL SPAR !—Thames (Hector, 1878).

PETROLEUM ! !—Sugar Loaves, Taranaki, from deep-seated coals, altered by volcanic dykes. A specific gravity, 0·960 to 0·964, rich in lubricants (Hector, Geol. Rep., 1866; Poverty Bay and Waiapu, deep wells and surface springs from Middle Jurassic strata (Hector, Geol. Rep., 1873). Paraffin oil, sp. gr. 0·843 to 0·872, yielded 64 per cent. to 84 per cent. kerosene (Skey).

PICROLITE !—Dun Mountain, coarsely fibrous, of a dark-green colour (Cox).

PICROSMINE !—Dun Mountain, associated with chromite, and is also found as a network of veins in which crystals of bronzite occur (Cox).

PIMELITE !—Malvern Hills, Clent Hills, filling cavities in amygdaloidal rocks (Haast).

PISTACITE !—West Coast, Mount Torlesse, Mount Somers, Wairarapa, in gneiss, granite, and granulite, and in melaphyres (Hector, Haast).

PITCHSTONE !—Mount Somers, Snowy Peak, associated with quartz porphyries (Haast).

PLATINIRIDIUM !—Takaka, Orepuke, as grains in gold-wash (Hochstetter).

PLATINUM (NATIVE) !—Collingwood and Takaka, Nelson (Hochstetter); Orepuke, Stewart Island, in the form of small flat grains of a steel-grey or white colour, associated with gold and zircons in southern goldfields, but it has never been found in reef (Hector).

PREHNITE !—Moeraki, Otepopo, Canterbury, in trap rocks (Hector, Daintree).

PROUSITE !—Thames (Hutton).

PSILOMELANE ! !—Waiheke, Waimakariri, Bay of Islands, Kawau, Wellington, massive, and is associated with manganite, forming a valuable ore. Analysis (Skey)—sample from Bay of Islands :—

Manganese oxides	75·46
Ferric oxide	11·76
Siliceous matters	2·74
Water	10·04
	100·00

PUMICE ! ! !—Tongariro, Tokano, Lake Taupo, Kereru, Ruapehu, &c., along the coast and on the banks of rivers, and on the plateaux round Lake Taupo, 2,000ft. above the sea-level, occurs also as pumice sand (McKay) at Kereru.

PYRITES (AURIFEROUS) ! !—Thames, Otago, as octahedral crystals in quartz reefs.

QUARTZ—*Amethyst* ! ! !—Rakaia Gorge, in an amygdaloidal trap; Canterbury, in the melaphyres (Haast).

Cellular Quartz ! !—Thames.

Ferruginous Quartz ! !—Abundant (Lab. and Geol. Reports, 1865).

Milk Quartz ! !—Everywhere, in the granites, schists, and slates.

Rose Quartz ! !—Rakaia Gorge, in trachyte and pitchstone (Haast).

Bloodstone !—Clent Hills, Snowy Peak, Malvern Hills, in small fragments (Haast).

Carnelian ! !—Malvern Hills, Mount Charles, Otago, in volcanic rocks (Hector).

Chalcedony ! !—Canterbury, Clent Hills, Gawler Downs, Tokatoka, Moeraki, Otepopo, &c., in "geodes" in the "melaphres" and quartz-porphyries (Hector, Haast, Hochstetter).

Chrysoprase !—Moeraki, Otepopo, Dunedin, Canterbury, Coromandel, filling cavities in amygdaloidal rocks (Haast).

Flint ! !—Kaipara and Clarence Valley, in chalk-marls (Hector);

Campbell Island, in chalk (Hector); Amuri Bluff, in limestone (Haast); Bay of Islands, Tapanui (Liversidge), (see Trans. N.Z. Inst.); Whangarei, in diatom earth (Hector).

Jasper! !—Coromandel, abundant in volcanic and porphyritic rocks (Hector); Snowy Range, as porcelain jasper (Haast); Auckland, in tuffs and conglomerates (Hochstetter).

Agate Jasper! !—Coromandel, in trachytic tuffs (Hector).

Plasma! !—Mount Somers and Gawler Downs, filling fissures in Tertiary quartzose trachyte (Haast); Moeraki and Otepopo, in volcanic rocks (Hector).

Potato Stone or *Geode*!—Snowy Ranges (Haast).

Pearl Sinter!—Rotorua.

Prase!—Gawler Downs, as small deposits in quartzose porphyritic trachytes (Haast, 1865).

Rock Crystal! ! !—Tamata, Kereru, Napier, Taupo, Canterbury, Milford Sound, in metamorphic schists, and derived from rhyolitic rocks (Lab. and Geol. Reports).

Silicious Sinter! !—Orakeikorako, surrounding thermal springs (Hochstetter); Te Tarata, in terraces.

Siderite! !—Mongonui, in cover of brown-coal beds (Hector, 1866).

Tridymite! !—Lyttelton Harbour, in trachytic rocks (Ulrich).

RETINITE, or AMBRITE! !—Hyde, Caversham, Tuapeka, Waitahuna, Dunstan, Bay of Islands, occurs as masses of altered kauri gum in brown coals. First mentioned by Hochstetter, also Hector (Geol. and Lab. Reports). Mean of three analyses by Richard Maly:—

Carbon	76·65
Hydrogen	10·38
Oxygen	12·78
Ash	·19
	100·00

RHODONITE, or MANGANESE SPAR!—Canterbury, Kawarau, Clutha, Dunstan, Waiheke, as veins in schists and as rolled fragments in alluvial drifts (Haast, 1865). Analysis (Skey):—

Silica	25·20
Sesquixode of iron	40·10
Protoxide of iron	1·20
Protoxide of manganese	18·85
Alumina	7·20
Copper	Traces.
Lime	3·02
Magnesic oxide	3·00
Water (constitutional)	1·43
	100·00

RUBELLANE!—Banks Peninsula (Haast).

SAPPHIRE!—Southern Alps and Collingwood, in alluvial gold beds (Haast, Hutton); determined by Skey.

Emery—Stewart Island.

SAUSSURITE!—Mount Torlesse, in gabbro (Haast).

SCHEELITE ! ! !—Lake Wakatipu, Buckle Burn, Rees River, Waipori, Richardson Mountains, Havelock, solid lodes and large rolled fragments, and in arsenical pyrites in the form of small grains (Hector 1863, McKay 1880).

SCHILLER SPAR !—West Coast, with iron pyrites (Hector).

SCHORL !—Bedstead Gully, Mosquito Hill, Resolution Island, in gneiss and in micaceous and hornblendic schists (Hector).

SCHRÖTTERITE !—Malvern Hills, filling the cavities in amygdaloidal trachytes, having a mammillated crust on its surface (Liversidge).

SELENITE, or GYPSUM ! !—Widely distributed throughout Canterbury, Auckland, Nelson, New Plymouth, &c., as groups of crystals associated with sulphur, or as nests of crystals in clay or marls. It is very plentiful, and is mentioned several times in the Geol. Surv. and Lab. Reports.

"SELEN-SULPHUR" !—White Island, massive dark yellow varieties of sulphur (Liversidge, Trans. N.Z.Inst., Vol. X).

SERPENTINE, or MARMOLITE — Mineral Belt, Nelson, and Dun Mountain, as common serpentine forming rock masses (Hochstetter); Milford Sound, noble serpentine, occurring with nephrite in thin veins (Hector). Analyses (Skey):—

	(I.)	(II.)	(III.)
Silica	40·20	41·20	45·91
Protoxide of iron	12·10	12·10	1·67
Alumina	Traces	Traces	5·63
Manganese	Traces	Traces	Traces
Chromium	Traces	Traces	Traces
Magnesia	33·20	34·02	35·07
Water (constitutional) ...	2·70	12·94	12·67
	98·20	100·06	100·95

SILVER ! !—Kawau Island, Lake Wakatipu, Waipori, also commonly alloyed with gold and as a component of tetrahedrite; Golden Crown Mine, as rolled fragments.

SMARAGDITE !—Red Hill, Collingwood, in diorite (Hector).

SPHÆROSIDERITE !—Mount Somers, Banks Peninsula, in volcanic and dyke rocks (Haast).

SPINEL—Manawatu and Waipori, Otago, Mount Somers, Canterbury, as rhombic dodecahedrons, nearly opaque (Hector).

STEATITE, or SOAPSTONE ! ! — Milford Sound, massive; Collingwood, foliated (Hector).

STIBNITE ! !—Otago, Endeavour Inlet, Reefton, Langdon's (Hector, 1865); Thames (Hutton, 1867); Endeavour Inlet (Cox, 1879), in schistose rocks.

STILBITE ! !—Karori, Mangawai, Tokatoka, Dunedin, as radiating pearly crystals forming films in joints of auriferous rocks (Skey), also in trachytic rocks as detached crystals (Haast, Liversidge).

SULPHUR ! ! !—White Island, debosited from fumaroles and geysers and from an enormous spring in the centre of White Island (Hector, 1865); Rotorua and Taupo districts, from hot springs (Hochstetter); Waipara, efflorescence from carbonaceous sandstones (Haast, 1870), efflorescence from pyritous reefs (Davis); Wangapeka. Analyses:—

	Liversidge.		Cox.	
Sulphur	99·614	98·888	99·9	62·5
Foreign matters ...	·386	1·112	·1	37·5
	100·000	100·000	100·00	100·00

TACHYLITE!—Banks Peninsula, Oamaru, on the sides of fissures where basaltic dykes have intruded (Haast).

TALC!!—West Coast, S.I., Jackson's Bay, Collingwood, in quartz, and associated with crystalline rocks (Hector).

TARANAKITE!—Taranaki, very much like wavellite; is a double hydrous phosphate of alumina and potash, part of the alumina being replaced by ferric oxide, discovered and described by Skey as a new mineral. Analysis per cent. (Skey):—

Phosphoric acid		35·05
Alumina		21·43
Ferrous oxide		4·45
Lime		·55
Potash		4·20
Soda		Traces
Chlorine		·46
Sulphuric acid		Traces
Insoluble in acid (silica)		·80
Water driven off at 212°	15·46	33·06
Water driven off at red heat	17·60	
		100·00

TETRAHEDRITE!—Collingwood, variety *Richmondite*, occurs as a lode at Richmond Hill. Analysis (Skey):—

Sulphide of lead	36·12
„ antimony	22·20
„ bismuth	Traces
„ copper	19·31
„ iron	13·59
„ zinc	5·87
„ silver	2·39
„ manganese	·52
	100·00

TIN!—Reefton, in quartz-grit (alluvial) (McKay, 1874); Stewart Island, in mica-gneiss (Prof. Black, 1888).

TOPAZ!—Chatto Creek, Arrow River, Waipori, in alluvium, mixed with rubies, garnets, &c. (Hector); Stewart Island, with tinstone (McKay); determined by Skey.

TREMOLITE!—Kanieri, Hokitika, Milford Sound, in quartzite (Hector).

VIVIANITE!—Dunedin, Awatere, as prismatic crystals in moa bones (Hector).

WAD!!—Auckland, Otago (Hector, 1864); Stewart Island (McKay, 1886).

WAVELLITE!—Taranaki, occurs in thin seams of a deep yellowish-brown colour, hard, translucent and infusible, traversing the taranakite in various directions (Skey).

WITHERITE or BARYTO-CALCITE!—Thames, in gold mines (Skey).

WOLFRAM!!—Stewart Island, with tinstone (McKay, 1889).

WOLLASTONITE!—Dun Mountain, massive in form. Analyses (Skey):—

	(I.)	(II.)	(III.)	(IV.)
Silica	48.01	49·30	50·62	58·80
Lime	46·20	45·91	44·88	24·60
Magnesia	Traces	·80	Traces	1·60
Alumina	1·45	1·41	1·84	12·20 (Alumina and Iron oxide)
Iron oxide	Traces	Traces	1·64	
Loss	2·19	1·19	Traces	1·40
Water	2·15	1·39	1·02	1·40
	100·00	100·00	100·00	100·00

WULFENITE!—Dun Mountain, as crystals of a flat tabular form.

ZINC-BLENDE!—Bedstead Gully, Tararu Creek, Great Barrier Island, associated with gold (Hector, Hutton). Analysis (Skey):—

Sulphide of zinc	77·61
" cadmium	Traces
" iron	20·14
Siliceous matter	2·25
	100·00

ZINCITE!—Collingwood (Skey).

ZIRCON!—Southern Alps, Timbrel's Gully, Doubtful Inlet, associated with platinum and gold and in the wash, and also in biotite rock (Hector).

INDEX TO FOSSILIFEROUS LOCALITIES IN NEW ZEALAND.

THE following is a list, brought up to date, of the numbers which distinguish the fossils in the Colonial Museum from each locality, and by which they are referred to in the Geological Reports, together with the formation in which the locality is placed according to the classification at present adopted in the work of the Geological Survey.

The year in which each collection was made is also given, to assist reference to the reports in which the localities are described, and the name of the collector is indicated as follows: H., Hector; Ha., Von Haast; Ht., Hutton; Cr., Crawford; C., Cox; M., McKay; B., Buchanan; P., Park; and a few others mentioned by name.

There are in addition many fossiliferous localities the collections from which, having been made during the provincial surveys of Canterbury by Von Haast, and of Otago, by Hector, are preserved in the Christchurch and Dunedin Museums, and are not included in this list.

Appended to this list is a brief descriptive index of the fossiliferous localities arranged according to the county in which they occur.

JAMES HECTOR,
Director.

30th June, 1891.

TABLE OF FOSSILIFEROUS FORMATIONS IN NEW ZEALAND.

I. Recent—
- *a.* Moa beds.
- *b.* Alluvia.
- *c.* Volcanic.
- *d.* Shingle-plains.

II. Pliocene—
- *a.* Shingle-plains.
- *b.* Pumice-sands.
- *c.* Lignite beds.
- *d.* Kereru beds.

III. Upper Miocene—
- *a.* Te Aute beds.
- *b.* Awatere beds.

IV. Lower Miocene—
- *a.* Ross beds.
- *b.* Mangapakeha beds.
- *c.* Paeroa beds.

V. Upper Eocene—
- *a.* Mount Brown beds.
- *b.* Oamaru beds.
- *c.* Nummulitic beds.

VI. Cretaceo-tertiary.
- *a.* Grey marls.
- *b.* Ototara stone.
- *c.* Fucoidal greensand.
- *d.* Amuri limestone.
- *e.* Island sandstone.
- *f.* COAL FORMATION OF NEW ZEALAND.
- *g.* Black-grit.
- *h.* Propylite breccias.
- *i.* Conglomerate.

VII. Neocomian—
- *a.* Conglomerates with coal.
- *b.* Prophyries.
- *c.* Greensands.

VIII. Jurassic—
- *a.* Mataura beds.
- *b.* Putataka beds.
- *c.* Flag Hill beds.

IX. Liassic—
- *a.* Catlin's River beds.
- *b.* Bastion beds.

X. Rhætic and Triassic—
- *a.* Otapiri beds.
- *b.* Wairoa beds.

XI. Permian—
- *a.* Oreti beds.. Great conglomerate. Great sandstones.
- *b.* Mount Potts bed. Kaihiku beds. Glossopteris beds.
- *c.* Conglomerates. Red sandstones.

[*Upper Carboniferous not yet identified.*]

XII. Lower Carboniferous—
- *a.* Maitai slates.
- *b.* Te Anau beds.

XIII. Lower Devonian—
Reefton beds.

XIV. Upper Silurian—
- *a.* Baton River Slates.
- *b.* Limestones.
- *c.* Serpentinous slates.

XV. Lower Silurian.
- *a.* Graptolite slates.
- *b.* Marbles.
- *c.* Hornblende rocks.

TABLE OF LOCALITIES AND FORMATIONS.

Locality.	Formation.
1. Fern beds, Kais Hill, Amuri Bluff, M., 1876 ...	VIII*a*.
2. Calcareous conglomerate, East Wing, Amuri Bluff, M., 1876	VII.
3. Belemnite bed, East Wing, Amuri Bluff, M., 1876	VII.
4. Trigonia beds, East Wing, Amuri Bluff, M., 1876 ...	VII.
5. Nummulite beds, Whareama, H., 1867	V*c*.
6. Aporrhais beds, East Wing, Amuri Bluff, M., 1876	VII.
7. Greensands, below black-grit, East Wing, Amuri Bluff, M., 1876	VII.
8. Black-grit, East Wing, Amuri Bluff, M., 1876 ...	VI*g*.
9. Boulder sands, East Wing, Amuri Bluff, M., 1876	VI*f*,
10. Concretionary greensand, East Wing, Amuri Bluff, M., 1876	VI*e*.
11. Teredo limestone, East Wing, Amuri Bluff, M., 1876	VI*e*.
12. Amuri limestone, Amuri Bluff, M., 1876	VI*d*.
13. Amuri group, West Wing, Amuri Bluff, M., 1876 ...	VII.
14. Oaro Creek, Amuri Bluff, M., 1876	VI*e*, *f*.
15. Old diggings (Hughie's), Buller River, Nelson, H., 1873; M., 1874	VIII*a*.
16. Lower Kaihiku Gorge, Otago (plants), M., 1873 ...	XI*b*.
17. Lower gorge of Purerua River, Otago, M., 1873 ...	XI*b*.
18. Lower gorge of Purerua River, Otago, M,, 1873 ...	XI*b*.
19. Old Mill, Owake Creek, Catlin's River, Otago, M., 1873	IX*a*.
20. Mouth of Catlin's River, Otago, M., 1873 ...	IX*a*.
21. Pholadomya Point, Catlin's River, Otago, H., 1865	IX*a*.
22. Greensands, Green Island, Otago, H., 1865; M., 1873	VI*e*.
23. Selwyn River, Canterbury, Ha., 1871	VI*e*, *f*.
24. Amuri Bluff, B., 1867	VII.
25. Amuri Bluff, Ha., 1869	VI., VII.
26. Callaghan's Hill, Westland, H., 1866	III*d*.
27. Ten-mile Creek, north of Cobden, Nelson, M., 1874	VI*f*.
28. Welshman's Terrace, Brighton, west coast of Nelson, M., 1874	VI*f*.
29. Brunner Mine, Grey River, Westland, H., 1870; M., 1873	VI*f*, *g*.
30. Morley Creek, Southland (Unio beds), H., 1869 ...	VI*g*.
31. Island sandstone, Woodpecker Bay, Brighton, west coast of Nelson, M., 1874	VI*f*.
32. Nine-mile Bluff, Cobden, west coast of Nelson, H., 1866; M., 1873	VI*f*.
33. Above Island sandstone, Woodpecker Bay, Brighton, west coast of Nelson, M., 1874	VI*e*.
34. Inland of White Rock Point, Mokihinui River, Nelson, M., 1874	VI*e*.
35. Cobden limestone, Greymouth, Westland, H., 1866	VI*d*.
36. Conway River, Marlborough, Ha, 1869	VI*d*.

	Locality.	Formation.
37.	Castlepoint, east coast of Wellington, H., 1867 ...	III*b*.
38.	Rainy Creek, Reefton, M., 1874...	VI*f*.
39.	Wangape Lake, Auckland, Ht., 1867	VI*d*.
40.	Tokomairiro limestone, Waihola Gorge, Otago, B., 1869; M., 1873	VI*b*.
41.	Black limestone, Tokomairiro, Otago, H., 1865 ...	VI*c*.
42.	Baton River, Nelson (quartz grit), H., 1867 ...	VI*f*.
43.	Raglan, west coast of Auckland, H., 1866 ...	VI.
44.	Mokihinui River, Nelson, M., 1874	IV*b*.
45.	St. Kilda, Brighton, west coast of Nelson, M., 1874	VI*f*.
46.	Seal Rock, Brighton, west coast of Nelson, H., 1870	VI*b*.
47.	The Castles, Slate River, Nelson, C., 1881 ...	V*a, b*.
48.	Inangahua Junction, Buller River, Nelson, H., 1873; M., 1874	VI*f*.
49.	Inangahua Ferry, Reefton, and Westport Road, Nelson, H., 1873; M., 1874	VI*c*.
50.	Christie's, Inangahua, Nelson, H. and M., 1874 ...	VI*e*.
51.	Aotea, west coast of Auckland, H., 1866... ...	VI*d*.
52.	White Cliffs, Taranaki. H., 1865 and 1878 ...	VI*a*.
53.	Caversham, Dunedin, Otago, H., 1869	VI*a*.
54.	Cape Turnagain, south coast of Napier, M., 1875 ...	II*a*.
55.	White Rock Point, north of Mokihinui River, Nelson, M., 1874	VI*a*.
56.	Coal-beds, Kokohu River, South Canterbury, Monro, 1869	VI*f*.
57.	Shakespeare Bay and Elevation, near Picton, Marlborough, H., 1865; Ht., 1872; M., 1874 ...	VI*a*.
58.	Point Elizabeth, Cobden, west coast of Nelson, H., 1866; M., 1874	VI*b*.
59.	Darkie Terrace, Cobden, west coast of Nelson, H., 1866; M., 1873	VI*b*.
60.	Poverty Bay, Auckland, H. and M., 1874 ...	VI*a*.
61.	Nummulitic limestone, Greymouth, H. and M., 1873	V*c*.
62.	Railway cutting, Jenkins's Hill, Nelson, M., 1874 ...	VI*d*.
63.	Lake Wakatipu, Otago, H., 1874	VI*c*.
64.	Cobden limestone, Greymouth, Westland, H., 1869; M., 1873	VI*b*.
65.	Bryant's, near Gisborne, Poverty Bay, H. and M., 1874	VI*a*.
66.	Mount Brown, Waipara, Canterbury, H., 1867; M., 1874	V*a*.
67.	Saurian Beds, Trelissick Section, Broken River, Canterbury, Enys and H., 1872; M., 1874 ...	VI*f*.
68.	Akuakua, east coast of Auckland (Venus beds), H. and M., 1874	VI*a*.
69.	Akuakua, east coast of Auckland (lower beds, Tertiary), H. and M., 1874	V*b*.
70.	Akukua, east coast of Auckland (upper beds, Tertiary), H. and M., 1874	IV*b*.
71.	Grey-marls, Weka Pass, Canterbury, H., 1867; M., 1874	VI*a*.

Locality.	Formation.
72. Te Wharepunga, east coast of Auckland, H. and M., 1874	VI*d*.
73. Limestone, Waipiro Bay, east coast of Auckland, M., 1874	VI*d*.
74. Weka Pass, calcareous greensands, Weka Pass, Canterbury, H., 1867; Ha., 1869; M., 1874 ...	VI*b*.
75. Kaihiku Gorge, Otago, B., 1869...	XI.
76. Whangaroa, North of Auckland, H. and M., 1866 ...	VI*f*.
77. Cape Kidnappers, Napier, H., 1866; M., 1875 ...	II*c*.
78. Cape Kidnappers, Napier, M., 1875	I*d*.
79. Cape Kidnappers, Napier, M., 1875	II*a*.
80. Scinde Island limestone, Napier, H., 1866 ...	II*a*.
81. Castlepoint, east coast of Wellington, M., 1875 ...	III*b*.
82. Hakarimata Range, Waikato, Auckland, C. and M., 1875	X*b*.
83. Waimarama, Napier, M., 1875	VII.
84. Paonui Point, Pourerere, Napier, M., 1875 ...	VII.
85. Mouth of Maungakuri River, Napier, M., 1875 ...	VII.
86. North bank of the Pourerere River, Napier, M., 1875	V*c*.
87. Nummulitic limestone, Paonui Point, Napier, M., 1875	V*c*.
88. Roparua and Tuparoa, east coast of Auckland, H. and M., 1874	VII.
89. Awanui, east coast of Auckland, M., 1874 ...	VII.
90. McDonald's Section, Poverty Bay, H. and M., 1874	VI*d*.
91. Lower part of Shakespeare Cliff, Wanganui, B., 1866	III*a*.
92. Upper part of Shakespeare Cliff, Wanganui, B., 1866	II*c*.
93. Taipos, east coast of Wellington, H., 1866 ...	IV*b*.
94. Taerua River, Wairarapa, Wellington, M., 1875 ...	III*b*.
95. Makara Valley, Wellington, M., 1876	III*b*. (?)
96. Raglan, plastic clays, C. and M., 1875	II*b*.
97. Limestone, five miles north of Raglan, west coast of Auckland, C. and M., 1875	V*b*.
98. Brown sandstone and flaggy limestone, Raglan, west coast of Auckland, C. and M., 1875 ...	VI*b*.
99. Leda marls, Raglan, west coast of Auckland, C. and M., 1875	VI*d*.
100. Leda marls, Miranda Redoubt, Auckland, C. and M., 1875	VI*d*.
101. Mercer, Waikato River, C. and M., 1875... ...	VI*d*.
102. Smyth River, Lake Heron, Canterbury, Ha., 1872...	VI*e*.
103. Cave Creek, Mount Somers, Canterbury, Ha., 1872	V*a*.
104. Fossil Point, Ashburton River, Canterbury, Ha., 1872	V*a*.
105. St. Peter's Mount, Whangaroa, North of Auckland (plants), H., 1866	III*d*.
106. Whangaroa, North of Auckland, M., 1875 ...	VII.
107. Kaeo River, Whangaroa, North of Auckland, M., 1875	VI*e*.

	Locality.	Formation.
108.	Ruamahanga River, Masterton, B., 1872...	IIId.
109.	Manawatu Gorge (lower end), B., 1872 ...	IIb.
110.	Culverden, Nelson, Ha., 1869 ...	Va.
111.	Whangara, Poverty Bay, East Coast of Auckland, H. and M., 1874	VIe.
112.	Coralline limestone, Raglan, C. and M., 1875	VIc.
113.	Pourerere River, Napier, M., 1875	IVb.
114.	Pourerere River, Napier, M., 1875	VII.
115.	Flanks of Castle Range, west of Pourerere, Napier, M., 1875	Vc.
116.	Waimarama, Napier, Enys, 1874; M., 1875	VIa.
117.	Mangapakeha Valley, east coast of Wellington, H., 1866; M., 1875	IVa.
118.	Akiteo River, east coast of Wellington, H., 1873; Enys, 1874...	VII.
119.	Akiteo River, east coast of Wellington, H., 1873 ...	Ic.
120.	Maraetotara River, Napier (Young Tertiary), M., 1875	IIb.
121.	Korakonui, east coast of Wellington, H., 1866	IVb.
122.	Waimarama, coast of Napier (Scinde Island beds), M., 1875	IIb.
123.	Kupakupa Coal-mine, Waikato, Auckland (plants), C. and M., 1875	VIg.
124.	Black marls, Mount Rochfort, M., 1874 ...	VIe.
125.	Fox River, Brighton, west coast of Nelson, M., 1874	IVb.
126.	Awatere River, Marlborough, B., 1867 ...	IIId.
127.	Awatere Point, Awanui, east coast of Auckland, M., 1874	VII.
128.	Mount Arthur, Nelson, H., 1867; M., 1879	XIVa.
129.	Rainy Creek, Reefton (Devonian), H. and M., 1874	XIII.
130.	Lankie's Gully, Reefton, H. and M., 1874	XIII.
131.	Lower Kaihiku Gorge, Otago, M., 1873 ...	XI.
132.	Wyndam River, Otago, B., 1866	IXa.
133.	Nugget Point, Otago, H., 1869; M., 1873	Xa.
134.	Wiltshire Beach, Molyneux Bay, Otago, M., 1873...	XIa.
135.	Upper Purerua Gorge, M., 1873	Xc.
136.	Mount Potts, Rangitata River, Canterbury, Ha., 1872	XIb.
137.	Benmore, Hokonui District, Southland, H., 1869 ...	Xa, b.
138.	Moonlight Range, Southland, Ht., 1872 ...	Xb.
139.	Richmond Hill, Nelson, H., 1866	Xb.
140.	Wairoa Gorge, Nelson, H., 1866	Xb.
141.	Wairoa Gorge, Nelson, M., 1874	Xb.
142.	Aniseed Valley, Nelson (Monotis beds), H., 1866...	Xb.
143.	Dun Mountain, Nelson, H., 1886; M., 1878	XIIa.
144.	Morley Creek, Southland, H., 1869	IXa.
145.	Otapiri Creek, Southland, H., 1869	IXa.
146.	Tautuku, Otago, H., 1869	IXa.
147.	Between Nugget Point and Cannibal Bay, Otago, M., 1873	IXa.

Locality.	Formation.
148. Mainland opposite Bloody Jack's Island, Otago, M., 1873	IX*a*.
149. McKay's Creek, Middle Waipara, Canterbury, M., 1874	VI*f*.
150. Grey-marls, Heathstock, Upper Waipara, Canterbury, M., 1874	VI*a*.
151. Okuku Range, west of Mount Grey, Canterbury, M., 1874	X*b*.
152. Weka Creek, Weka Pass, Canterbury, M., 1874 ...	VI*f*.
153. Callaghan's Hill, Westland, C. and M., 1875 ...	III*d*.
154. Kanieri River, Westland, C. and M., 1875 ...	IV*b*.
155. Ross, Westland, C. and M., 1875	III*c*.
156. Abbey Rocks, Paringa District, Westland, C. and M., 1876	VI*e*.
157. Kaikoura Peninsula, Marlborough, M., 1876 ...	VI*f*.
158. Amuri Bluff Hill, M., 1876	II*a*.
159. Mount Grey Downs, Canterbury, M., 1874 ...	IV*b*.
160. Grey Stream, Mount Grey, Canterbury, M., 1874 ...	IV*b*.
161. Nugget Point, Otago, B., 1866	X*a*.
162. Weka Pass stone, Kokohu River, South Canterbury, M., 1876	VI*b*.
163. Greensands overlying coal, Kokohu River, S. Canterbury, M., 1876	VI*e*.
164. Coal-beds, Kokohu River, South Canterbury, M., 1876	VI*f*.
165. White Rock River, Upper Pareora River, Canterbury, M., 1876	IV*b*.
166. Lower Gorge, Pareora River, Canterbury. M., 1876	IV*b*.
167. Lower Gorge, Pareora River (coal-beds), M., 1876; Enys, 1879	VI*f*.
168. Otepopo River, Oamaru, Otago, M., 1876 ...	VI*e*.
169. Kakanui limestone, Kakanui, Otago, M., 1876 ...	V*b*.
170. Awamoa Creek, Oamaru, Otago, M. 1876 ...	IV*b*.
171. Cape Wanbrow to breakwater, Oamaru, Otago, M., 1876	VI*e*.
172. Hutchinson's Quarry, Oamaru, M., 1876 ...	V*b*.
173. Limekiln Gully, Oamaru, Otago, M., 1876 ...	V*b*.
174. Devil's Bridge, Oamaru Creek, Otago, M., 1876 ...	V*b*.
175. One mile south of Devil's Bridge, Oamaru Creek, Oamaru, M., 1876	IV*b*.
176. Black Point, Waitaki River, Otago, M., 1876 ...	VI*e*, *f*.
177. Maerewhenua gold-workings, Otago, M., 1876 ...	VI*f*.
178. Phorus beds, Maerewhenua, Waitaki, Otago, M., 1876	VI*a*.
179. Maerewhenua limestone, Waitaki, Otago, M., 1876	VI*b*.
180. Dorset's Forty-mile Bush, Wellington, M., 1877 ...	III*b*.
181. Manawatu Gorge, Wellington (upper end), M., 1877	III*b*.
182. Manawatu Gorge, Wellington (lower end), M., 1877	II*b*.

	Locality.	Formation.
183.	Norsewood, Seventy-mile Bush, Napier, M., 1877...	II*b*.
184.	Porangahau Creek, Ruataniwha Plains, Napier, M., 1877	II.
185.	Johnston's Ruataniwha Plains, Napier (shell limestone), M., 1877	II*c*.
186.	Waipawa River, Napier, M., 1877.	VI*d*.
187.	Stokes's Run, Te Aute Hills, Napier (shell limestone), M., 1877	III*b*.
188.	Kereru, inland from Napier (Rotella beds), M., 1877	II*c*.
189.	Kereru, inland from Napier (limestone), M., 1877 ...	III*b*.
190.	Kereru, inland from Napier (lower beds), M., 1877	III*b*.
191.	Shrimpton's, Ngarurora River, Napier (upper), M., 1877	II*a*.
192.	Shrimpton's, Ngarurora River, Napier (middle), M., 1877	II*a*.
193.	Shrimpton's, Ngarurora River, Napier (lower), M., 1877	II*b*.
194.	Scinde Island, Napier, M., 1877	II*c*.
195.	Plant-beds, Eighty-eight Valley, M., 1878 ...	IX*a*.
196.	Trigonia beds, Eighty-eight Valley, M., 1878 ...	IX*a*.
197.	Spiriferina beds, Eighty-eight Valley, M., 1878 ...	IX*a*.
198.	Hokianga, Auckland (Tertiary beds), H., 1874 ...	IV*b*.
199.	Morrison's, North of Auckland (coal-beds), H., 1874	VI*e*, *f*.
200.	Evans's Bay, Wellington Harbour, M., 1876 ...	I*c*.
201.	Taipos, east coast of Wellington, M., 1875 ...	IV*b*.
202.	Turanganui, Poverty Bay, Gisborne (No. 1), H. and M., 1874	I*c*.
203.	Turanganui, Poverty Bay, hill east of river (No. 2), H. and M., 1874	II*a*.
204.	Turanganui, Poverty Bay, McDonald's section (No. 3), H. and M., 1874.	II*b*.
205.	Durie's Hill, Wanganui, Kirk, 1875	II*b*.
206.	Shakespeare Cliff, Wanganui (upper part), Kirk, 1875	II*c*.
207.	Railway cutting, ten miles from Wanganui, Kirk, 1875	II*a*,
208.	Lower part of Shakespeare Cliff, Wanganui, Kirk, 1885	III*a*.
209.	Waitotara, west coast of Wellington, H., 1870 ...	III*d*.
210.	Mount Reilly, New River District, Westland, M., 1874	III*c*.
211.	New River, Westland, (Tertiary), H., 1869 ...	III*d*.
212.	Ormond, Poverty Bay, M., 1874	II*a*.
213.	Awamoa, Oamaru, Otago, Traill, 1865	IV*b*.
214.	Hampden, Otago, Traill, 1865	IV*b*.
215.	Sherry River, Nelson, H., 1867	VI*e*.
216.	Mount Caverhill, Nelson, Ha., 1869	IV*b*.
217.	Cape Kidnappers and Te Aute Hills, H., 1867 ...	II*a* to III*b*.
218.	Motunau, Canterbury, B., 1867	IV*b*.
219.	Motunau, Canterbury, B., 1867	II*a*.

	Locality.	Formation.
220.	Petane, Hawke's Bay, Napier (shell limestone), C., 1876	II*a*.
221.	Petane, Hawke's Bay, Napier (sandy clays) C., 1876	II*b*.
222.	Watchman's Island, Napier Harbour, Williams, 1878	II*c*.
223.	North side of Tokomaru Bay, M., 1874	IV*b*.
224.	Kakanui River, Oamaru, Otago, M., 1876 ...	VI*e*.
225.	Gilligan's, Westland, H., 1869	III*d*.
226.	Upper Trelissick, Enys and H., 1872	IV*b*.
227.	Kanieri, Westland, H., 1869	IV*b*.
228.	Lower gorge of the Waipara, Canterbury, H., 1867	IV*b*.
229.	Manawatu Gorge, B., 1874	II*b*.
230.	Kaipuki Cliffs, Nelson, H., 1867	V*a*.
231.	McLean's, Ngaruroro River, Napier, H., 1871 ...	II*b*.
232.	Hurunui Mound, Nelson, Ha., 1869	IV*b*.
233.	Waikare, Canterbury, H., 1872...	IV*b*.
234.	Lake Lyndon, West Coast Road, Canterbury, H., 1872	IV*b*.
235.	Plant-beds, road-cutting, Thomas River, Trelissick Basin, M., 1874	III.
236.	Pareora beds, Thomas and Porter Rivers, Trelissick Basin, M., 1879	IV*b*.
237.	Upper part of Mount Brown limestone, Trelissick Basin, M., 1879	V*a*.
238.	Mount Brown limestone, Coleridge Creek, Trelissick Basin, Enys, 1866, 1879	V*a*.
239.	Fan-coral bed, Porter and Thomas Rivers, Trelissick Basin, M., 1879...	V*c*.
240.	Below Weka Pass stone, Porter River, Trelissick Basin, M., 1879	VI*b*.
241.	Tufaceous greensands, Whitewater Creek, Trelissick Basin, M., 1879	VI*e*.
242.	Weka Pass stone, Trelissick Basin, Enys, 1866, 1879	VI*b*.
243.	Fan-coral bed, Trelissick Basin, Enys, 1866, 1879...	V*c*.
244.	Pareora beds, Trelissick Basin, Enys, 1866, 1879 ...	IV*b*.
245.	Castle Rock, Southland, M. 1878	IV*b*.
246.	Cape Rodney, Auckland, H., 1866; C., 1879 ...	IV*b*.
247.	Forest Hill Range, Southland, M., 1878	V*a*.
248.	Waitaki River, Otago, H., 1865	V*c*.
249.	Duncan's, east coast of Auckland, H. and M., 1874	IV*b*.
250.	Aohanga Falls, Akateo River, east coast of Wellington, H., 1873	IV*b*.
251.	Wharekauri, Traill, 1874	V*c*.
252.	Otakaika, Traill, 1874...	V*c*.
253.	Pakeuri, Traill, 1874	V*c*.
254.	Awamoa, Traill, 1874	IV*b*.
255.	Cape Hills, Oamaru, Traill, 1874	V*b*.
256.	Grey marls, Otapiri Creek, Southland, M., 1878 ...	VI*a*.
257.	Kawau Island, H., 1866	IV*b*.

Locality.	Formation.
258. Waimea Plains, Southland (limestone), H., 1869	V*a*.
259. Parakino and Upper Wanganui Rivers, Cr., 1862	III., IV.
260. Hautapu Falls, Rangitikei River, H., 1870 ...	III.
261. Tataka River, Nelson, H., 1868	V*a*.
262. Orepuki, Southland, H., 1869	V*b*.
263. Hicks Bay, Auckland, H., 1874	IV*b*.
264. Flaxbourne, Marlborough, M., 1876	VI*f*.
265. Flaxbourne, Marlborough, M., 1876	III*d*.
266. Point Elizabeth, Cobden, Nelson, H.	VI.*b*
267. Waikato Heads, C., 1876	VIII*b*.
268. Aotea sandstone, between Raglan and Kupakupa, Waikato, C., 1876	VI*b*.
269. Limestone, between Raglan and Kupakupa, Waikato, C., 1876	VI*b*.
270. Parua Bay, Whangarei, Auckland, C., 1876 ...	VI*f*.
271. Walton's Coal-mine, Whangarei, Auckland, H., 1865	VI*e*.
272. Waikawau Creek, Waikato, Auckland, C., 1876 ...	VI*a*.
273. Whangape Lake, Ht., 1866	VI*d*.
274. One mile below Lyell, Buller River, Nelson, H. 1869	VI*f*.
275. Grey marls, Weka Pass stone, and greensand conglomerate, east wing Amuri Bluff, M., 1876 ...	VI*a*, *b*.
276. Kawhia Harbour, west coast of Auckland, H., 1866	VIII*b*.
277. Bobbie's Creek, Waipara District, Canterbury, H., 1867	VI*f*.
278. Source of the Mokihinui River, Nelson, H., 1867 ...	VI*c*.
279. Whangarei and Kawakawa, Auckland, H., 1866 ...	VI*f*.
280. Measley Beach, Otago, H., 1869	VI*f*, *e*.
281. Between Ngakawau and Mokihinui Rivers, Buller District, H., 1871	VI*f*.
282. Whangarei, Auckland, C., 1867...	VI*f*.
283, 275. Tiger Hill, Whangarei, Auckland, H., 1867 ...	VI*f*.
284. Morrison's District, North of Auckland, H., 1874...	VI*c*.
285. Grey-marls, Hawke's Bay, northern district, C., 1876	VI*a*.
286. Cobden limestone, Marsden Road, Greymouth, M., 1873	VI*b*.
287. Tokomaru Bay, east coast of Auckland, M., 1874...	VI*a*.
288. Waireka Valley, Oamaru, Otago, M., 1876 ...	VI*d*.
289. Port Waikato, Auckland, C., 1876	VIII*b*.
290. Marsden, New River District, Westland, M., 1873...	V*c*.
291. Maitai formation, Westland, M., 1875	XII*a*.
292. Great Barrier Island, Ht., 1866	XIV*a*.
293. Hapuka River, Looker-on Mountains, Marlborough, M., 1876	VI*e*, *f*.
294. Kaikoura Peninsula, Marlborough, M., 1876 ...	VI*c*.
295. Saurian beds, Heathstock Junction, Upper Waipara, M., 1874	VI*f*.
296. Fossil Point, Cape Farewell, Nelson, H., 1868 ...	V*a*.
297. Orakei Bay, Auckland, H., 1866	VI*a*.

	Locality.	Formation.
298.	Surveyors' Gully, Malvern Hills, Canterbury ...	VI*f*.
299.	Breakwater, Oamaru, Otago, M., 1876	I*c*.
300.		
301.	Coral-beds, Waikawau Creek, Waikato, Auckland, C., 1876	VI*a*.
302.	Tata Island, Nelson, H., 1868	III.
303.	Clifton, Nelson, H., 1868	III.
304.	Culverden, Nelson, M., 1874	V*a*.
305.	Black-birch Creek, Nelson Ha., 1869	V*a*.
306.	Marble Point, Waiau-ua River, Nelson, Ha., 1869	V*a*.
307.	Grey-marls, Cuff's Oil-springs, Poverty Bay, Auckland, H. and M., 1874	VI*a*.
308.	Oamaru, Otago, H., 1876	V*b*.
309.	Caversham, Dunedin, Otago, M., 1876	VI*a*.
310.	Interbedded with volcanic rocks, Oamaru Creek, Oamaru, M., 1876	V*c*.
311.	Curiosity Shop, Rakaia River, Canterbury, 1879 ...	V*a*.
312.	South-west side of Oamaru Cape, Otago, M., 1876	V*b*.
313.	Dean's, Waipara River, Canterbury, H., 1872 ...	V*a*.
314.	Cape Campbell, M., 1876	VII.
315.		
316.		
317.	Te Aro, Wellington	I*c*.
318.	Wairoa Gorge (Tertiary beds), M., 1878	IV*b*.
319.	Port Hills, Nelson, M., 1874	IV*b*.
320.	Shag Point, Otago (shells), H., 1865	VI*f*.
321.	Waiau-ua River, Marlborough, B., 1867 ...	VI*d*.
322.	Below flaggy limestone, Waikato Heads, C., 1877...	VI*c*.
323.	Cardita beds, Waikawau Creek, Waikato, C., 1877	VI*a*.
324.	Marls, Baton River, Nelson, H., 1868	VI*e*.
325.	Red Cliff, Rakaia River, Canterbury, M., 1874 ...	III*d*.
326.	Red Cliff, Rakaia River, Canterbury, M., 1874 ...	V., VI.
327.	Awamoa Bridge, Oamaru, South Road, M., 1876 ...	V*b*.
328.	Cook's Cove, Tolago Bay, east coast of Ackland, M., 1874	IV*b*.
329.	Pomahaka River, Otago H., 1869	IV*b*.
330.	Ngaruroro Gorge, Napier, M., 1877	III*c*.
331.	Dunedin Harbour	I*c*.
332.	Inoceramus beds, Makarewa, Hokonui Hills, Southland, C. and M., 1877	VIII*b*.
333.	Avicula beds, Flag Hill, Hokonui District, Southland, C. and M., 1877	VIII*b*.
334.	Astarte beds, lower end of Otapiri Gorge, Southland, C. and M., 1877	VIII*b*.
335.	Astarte beds, road-cutting, north side of Peel Hill, C. and M., 1877	VIII*b*.
336.	Astarte beds, top of Flag Hill, C. and M., 1877 ...	VIII*b*.
337.	Highest Spirifer bed, Conical Hill, Otapiri Gorge, M., 1878	VIII*b*.
338.	Highest Spirifer bed, table-land above Tree Bluff, Otapiri Gorge, M., 1878	VIII*b*.

No.	Locality.	Formation.
339.	Highest Spirifer bed, north face of Flag Hill, M., 1878	VIII*b*.
340.	Highest Spirifer bed, Upper Lora, behind Taylor's Station, M., 1878	VIII*b*.
341.	Lower Belemnite beds, north face of Flag Hill, M., 1878	VIII*b*.
342.	Little Spirifer grit, north face of Flag Hill, M., 1878	VIII*c*.
343.	Upper Plagiostoma bed, west face of Flag Hill, M., 1878	IX*a*.
344.	Upper Plagiostoma bed, north face of Flag Hill, M., 1878	IX*a*.
345.	Upper Plagiostoma bed, west face of Bastion Hill, M., 1878	IX*a*.
346.	Saddle between Taylor's Creek and Lora Station, M., 1878	IX*a*.
347.	Upper Ammonite bed, west face of Flag Hill, M., 1878	IX*a*.
348.	Higher part of Lower Plagiostoma bed, M., 1878 ...	IX*a*.
349.	Lower part of Lower Plagiostoma bed, M., 1878 ...	IX*a*.
350.	Between lower part of Lower Plagiostoma bed and Middle Ammonite bed, M., 1878	IX*a*.
351.	Overlying Upper Cannon-ball sandstone, Flag Hill to North Peak section, M., 1878	IX*a*.
352.	Middle Ammonite bed, Otapiri Creek, M., 1878 ...	IX*a*.
353.	Middle Ammonite bed, slopes of Bare Hill, behind Taylor's Station, Lora Stream, M., 1878 ...	IX*a*.
354.	Lower Ammonite bed, Taylor's Creek, junction of south branch; Flag Hill to North Peak section, M., 1878	IX*a*.
355.	Lower Ammonite bed, junction of Taylor's Creek and Otapiri, M., 1878	IX*a*.
356.	Below Lower Ammonite bed, junction of Taylor's Creek and Otapiri, M., 1878	IX*a*.
357.	Lower part of Lower Ammonite bed, Flag Hill to North Peak section, M., 1887	IX*a*.
358.	Lower part of Lower Ammonite bed, Taylor's Creek, below the woolshed, M., 1878	IX*a*.
359.	Lower Cannon-ball sandstone, Taylor's Creek, M., 1878	X*a*.
360.	Below Lower Cannon-ball sandstone, Taylor's Creek, M., 1878	X*a*.
361.	North-west branch of Taylor's Creek, above Trigonia beds, M., 1878	X*a*.
362.	Taylor's Crossing, Otapiri Creek, M., 1878 ...	X*a*.
363.	Benmore Yards, M., 1878	X*a*.
364.	Trigonia beds, north-west branch of Taylor's Creek, M., 1878	X*a*.
365.	Blue sandstone, north-west branch of Taylor's Creek, M., 1878	X*a*.
366.	Blue sandstone and chert, main branch of Taylor's Creek, M., 1878	X*a*.

	Locality.	Formation.
367.	Banks of the Otapiri Creek, one mile above Taylor's Crossing, M., 1878	X*a*.
368.	Trigonia beds, slopes of the southern peak of Benmore Range, M., 1878	X*a*.
369.	Benmore sandstone, south peak, Benmore Range, M., 1878	X*a*.
370.	Lowest bed of the Otapiri series, north-west branch of Taylor's Creek, M., 1878	X*a*.
371.	Benmore sandstone, Benmore railway-cutting ...	X*a*.
372.	Oreti railway cutting, M., 1878	X*a*.
373.	Monotis sandstone, Oreti Railway-station, M., 1878	X*b*.
374.	Monotis sandstone, southern peak of Benmore Range, M., 1878	X*b*.
375.	Monotis sandstone, north-west branch of Taylor's Creek, M., 1878	X*b*.
376.	Railway-cutting, north of Oreti Railway-station M., 1878	X*b*.
377.	Ash-beds, North Peak section, M., 1878 ...	XI*a*.
378.	Inoceramus beds, overlying Big Conglomerate, Oreti River, M., 1878	XI*a*.
379.	Spirigera beds, overlying Big Conglomerate, Oreti River, M., 1878	XI*a*.
380.	Spirifer and Crinoid beds, near Cowan's Railway-station, M., 1878	XI*c*.
381.	Spirifer and Crinoid beds, North Peak, M., 1878. ...	XI*c*.
382.	Wairoa Gorge, M., 1875	X*b*.
383.	*Mytilus problematicus* bed, west side of Mount Wellington, Wairoa Gorge, M., 1878–79 ...	X*b*.
384.	Halobia bed, east side of Mount Wellington, Wairoa Gorge, M., 1878–79	X*b*.
385.	Nautilus bed, east side of Mount Wellington, Wairoa Gorge, M., 1878–79	X*a*.
386.	Monotis sandstone, eastern slopes of Mount Wellington, Wairoa Gorge, M., 1878–79 ...	X*b*.
387.	*Mytilus problematicus* beds, east slopes of Mount Wellington, Wairoa Gorge, M., 1878–79 ...	X*b*.
388.	Limestone, Martin's saw-mill, upper end of Wairoa Gorge, M., 1878–79	XII*a*.
389.	Limestone, upper end of Wairoa Gorge, M., 1878–79	XII*a*.
390.	Spirifer beds, upper part of Spring Grove Creek, Wairoa Gorge, M., 1878	X*b*.
391.	Monotis sandstone, Spring Grove Creek, Wairoa Gorge, M., 1878	X*b*.
392.	Top of the range, head of Spring Grove Creek, Wairoa Gorge, M., 1878	X*b*.
393.	Lowest beds, Sellen's section, West Wairoa Gorge, M., 1878	X*b*.
394.	Spirigera beds, Sellen's section, Wairoa Gorge, M., 1878	X*b*.

Locality.	Formation.
395. *Mytilus problematicus* beds, Sellen's section, Wairoa Gorge, M., 1878–79	X*b*.
396. Great limestone, Sellen's, Wairoa Gorge, M., 1878–79	XII*a*.
397. Productus limestone, Sellen's, Wairoa Gorge, M., 1878–79	XII*a*.
398. Fossiliferous slates, Little Ben, Wairoa River, M., 1878	XII*a*.
399. Fossiliferous slates, Dun Mountain Tramway, M., 1878	XII*a*.
400. Upper Gorge of the Maitai River, M., 1878 ...	XII*a*.
401. Mount Potts Spirifer beds, M., 1877	XI*a*.
402. Mount Potts Glossopteris beds, M., 1877 ...	XI*a*.
403. Seaward Downs, H., 1868	VIII*a*.
404. Taylor's Creek (plants), M., 1878	IX*a*.
405. Clent Hills (plants), Ha., 1872	VIII*a*.
406. Mataura (plants), B., 1863; M., 1879	VIII*a*.
407. Otapiri (plants), H., 1869	VIII.
408. Owake Creek (plants), H., 1865	VIII*a*.
409. Waikato Heads (plants), H., 1866	VIII.
410. Pakawhau Coalfield (plants), H., 1868	VI*g*.
411. Buller Coalfield, H., 1869	VI*f*.
412. Grey Coalfield, H., 1869	VI*f*.
413. Wangapeka, H., 1868	VI*f*.
414. Shag Point, B., 1869	VI*f*.
415. Mount Hamilton, H., 1869	VI*f*.
416. Whangarei (coal), H., 1866	VI*f*.
417. Kawakawa, H., 1866	VI*f*.
418. Whangaroa, H., 1866	III*d*.
419. Cromwell	VI.
420. Landslip Hill (plants), H., 1869	VI.
421. Mongonui (plants), H., 1866	II*c*.
422. Knight's Hut, Malvern, H., 1869	VIII.
423. Surveyors' Gully, Malvern, Ha., 1869	VI*f*.
424. Jebson's Mine, Malvern, H., 1869	VI*f*.
425. Trelissick (plants), H., 1872	VI*f*.
426. Waikawa (plants), H., 1865	VIII*a*.
427. Morley Creek and Linton, H., 1869	VI*f*.
428. Abbey Rocks, C., 1875	VI.
429. Mount Torlesse Annelid bed, H., 1869	XII*a*.
430. Karori sandstone, Wellington, H., 1866 ...	XII*a*.
431. Graptolite slates, Collingwood, ...	XIV*b*.
432. Monotis beds, Eighty-eight Valley, Nelson, M., 1878	X*b*.
433. Halobia beds, Eighty-eight Valley, Nelson M., 1878	X*b*.
434. Mytilus beds, Eighty-eight Valley, Nelson, M., 1878	X*b*.
435. Psioidea beds, Eighty-eight Valley, Nelson, M., 1878	X*b*.
436. Kaihiku beds, Eighty-eight Valley, Nelson, M., 1878	XI*a*.

	Locality.	Formation.
437.	Nautilus beds, Mount Wellington, Wairoa Gorge, Nelson, M., 1878	X*a*.
438.	Monotis beds, Mount Wellington, Wairoa Gorge, Nelson, M., 1878	X*b*.
439.	Mytilus beds, Mount Wellington, Wairoa Gorge, Nelson, M., 1878	X*b*.
440.	Psioidea beds, Mount Wellington, Wairoa Gorge, Nelson, M., 1878	X*b*.
441.	Limestone, Martin's Mill, Wairoa Gorge, Nelson, M., 1878	XII*a*.
442.	Mytilus beds, north side of Wairoa Gorge, Nelson, M., 1878	X*b*.
443.	Psioidea beds, north side of Wairoa Gorge, Nelson, M., 1878	X*b*.
444.	Graham River, Motueka Valley, Nelson, M., 1879	XIV*a*.
445.	Dart River, Wangapeka, Nelson, M., 1879 ...	XIV*a*.
446.	Rolling River, Wangapeka, Nelson, M., 1879 ...	XIV*a*.
447.	Rolling River, Wangapeka, Nelson, M., 1879 ...	XIV*b*.
448.	Source of Clark River, Wangapeka, Nelson, 1879 ...	XIV*a*.
449.	Lower beds, Trelissick Basin, Enys, 1880 ...	VI*e*.
450.	Cape Rodney, Auckland, C., 1880	IV*b*.
450A.	Mount Brown beds, Coleridge Creek, Trelissick Basin, Enys	V*a*.
451.	Komiti Point, Kaipara, Auckland, C., 1880 ...	VI*a*.
451A.	Pareora beds, Thomas and Porter Rivers, Trelissick Basin, Enys	IV.
452.	Mataura River, west bank, below falls, M., 1879 ...	IV.
452A.	Plant-bed with shells, road-cutting, and Porter River, Trelissick Basin, Enys	IV.
453.	Mohaka River, Auckland, H., 1871	III*b*.
453A.	Upper surface of Mount Brown limestone, Trelissick Basin (old collection)	
454.	Kawakawa, Auckland, C., 1879	VI*e,f*.
454A.	Mount Brown limestone, Coleridge Creek, Trelissick Basin, M.	
455.	Monotis beds, Okuku Range, Canterbury, M., 1879	X*b*.
456.	Cretaceo-tertiary beds, Lake Wakatipu, Otago, M., 1880	VI*e*.
456A.	Pareora beds, Thomas and Porter Rivers (old collection)	IV*b*.
457.	Pareora beds, Lake Wakatipu, Otago, M., 1880 ...	IV*b*.
458.	Lower part of Pareora River, Canterbury, Enys, 1879	IV*b*.
459.	Mouth of Wyndham River, Otago, M., 1879 ...	IX*a*.
460.	Otapiri beds, Wharfdale, Ashley River, Canterbury, M., 1879	X*a*.
461.	One mile below Mataura Falls, Otago, M., 1879 ...	IX*a*.
462.	Baton River, near junction of the Clark River, Nelson, M., 1879	VI*e*.
463.	Near mouth of the Clark River, Baton River, Nelson, M., 1879	VI*d*.

	Locality.	Formation.
464.	Limestone Island, Whangarei, Auckland, C., 1879	V.
465.	Opposite Captain Colbeck's, Kaipara, Auckland, C., 1880	V.
466.	Clark's Cutting, Whakahara, Auckland, C., 1879 ...	VI*a*.
467.	Tangitiroria (Wilson's), Wairoa River, Auckland, C., 1879	VII.
468.	Pareora beds, Wairoa Gorge, Nelson, M., 1878 ...	IV*b*.
469.	Ostrea beds, south of Selwyn River, Malvern Hills, Canterbury, M., 1879	VI*f*.
470.	East bank of Mataura River, one and a half miles below bridge, M., 1879	VIII*c*.
471.	East bank of Mataura River, one mile below bridge, M., 1879	VIII*c*.
472.	Popotuna Gorge, Otago (east end), M., 1879 ...	XI*a*.
473.	Sellen's, Eighty-eight Valley, M., 1879	XII*a*.
474.	Limestone Bluff, Ashburton River, Canterbury, C., 1876	V*a*.
475.	Mount Harris, Waihoa River, Canterbury, M., 1880	IV*b*.
476.	Kekenodon beds, Waitaki River, Otago, M., 1880 ...	V*d*.
477.	Otakaika limestone, Station Peak, Waitaki, Otago, M., 1880	V*c*.
478.	Otakaika limestone, Wharekauri, Waitaki, Otago, M., 1880	V*c*.
479.	Marly greensands, Waihoa River, Canterbury, M., 1880	VI*e*.
480.	Island sandstone, Waihoa River, Canterbury, M., 1880	VI*e*.
481.	Otakaika limestone, Otakaika, M., 1880	V*c*.
482.	Waihoa limestone, Waihoa River, Canterbury, M., 1880	VI*b*.
483.	Hutchinson's Quarry beds, Wharekauri, Waitaki Valley, Otago, M., 1880	V*b*.
484.	Maerewhenua limestone, Pigeon Rock, Waitaki Valley, Otago, M., 1880	VI*b*.
485.	Grey-marls, Waihoa River, Canterbury, M., 1880 ...	VI*a*.
486.	Wharekauri greensand, Wharekauri, Waitaki Valley, Otago, M., 1880	VI*c*.
487.	Concretions with fossils overlying coal-beds, Ngapara, Waireka Valley, Oamaru, Otago, M., 1882	VI*e*.
488.	Limonitic sandstone (decomposed greensands), Government dam, Mount Ida Water-race, Naseby, Maniototo, Otago, M., 1883	VI*e*.
489.	Ototara limestone, Isolated Hill, north side of Kakanui Mouth, Oamaru, Otago, M., 1882 ...	VI*b*.
490.	Volcanic breccia with shells under Ototara stone, Isolated Hill, North Kakanui Mouth, Oamaru, Otago, M., 1882	VI*c*. (?)
491.	Hutchinson's Quarry beds, Oamaru Creek, Town of Oamaru, Otago, M., 1882	V*b*.

	Locality.	Formation.
492.	Hutchinson's Quarry beds, northern end of Awamoa Beach, Oamaru, Otago, M., 1882	V*b*.
493.	Pareora beds, Kyeburn (upper township) Diggings, Maniototo, Otago, M., 1883	IV*c*.
494.	Hutchinson's Quarry beds, Kyeburn (upper township) Diggings, Maniototo, Otago, M., 1883 ...	V*b*.
495.	Ototara limestone, Cave Valley and upper part of Oamaru Creek, Oamaru, Otago, M., 1882 ...	VI*b*.
496.	Maerewhenua limestone, crossing of Awamoko Creek, north of Ngapara, Oamaru, Otago, M., 1882	VI*b*.
497.	Marls overlying nummulitic limestone, Greymouth, Westland, M., 1882	IV*c*. (?)
498.	Marls under or = in part Ototara stone, cliffs on left bank of Kakanui River, opposite Maheno, Oamaru, Otago, M., 1882	VI*b*, *c*.
499.	Marls under Ototara limestone, Cape Hills, northern end of Awamoa Beach, Oamaru, M. 1883 ...	VI*c*.
500.	Marls under Otatara limestone, Cape Valley, Oamaru, M., 1883	VI*c*.
501.	Hampden (Onekakara) Beach and Moeraki Peninsula, Moeraki District, Otago, M., 1883 ...	VI*e*.
502.	Coast Range (west slope), Cheviot Hills Station to Waiau-au River, M., 1882	VI*c*.
503.	Chalk-marls, Happy Valley Creek, Motunau Flats, North Canterbury, M., 1882	VI*c*.
504.	Miocene beds, Happy Valley Creek, Motunau Flats, North Canterbury, M., 1882	IV*c*.
505.	Upper Miocene beds, near Cheviot Station, Cheviot Hills, Amuri District, Nelson, M., 1882 ...	III*b*.
506.	Swinburn, south-east corner of Maniototo Plain, Otago (calcareous sandstone), M., 1883 ...	VI*b*.
507.	Green Valley, Upper Shag River, Waihemo, Otago, M., 1883	VI*e*.
508.	Coal-beds, Reefton, Nelson (plants), M., 1882 ...	VI*f*.
509.	Coal-beds, Brunnerton, Grey Valley, Nelson, M., 1882	VI*f*.
510.	Bannockburn, Cromwell, Vincent County, Otago (plants), 1882	IV.
511.	Bannockburn, Cromwell, Vincent County, Otago, M., 1882 (shells and fish-remains)	IV. (?)
512.	St. Bathan's, Manuherikia Valley (plants), M., 1883	III. (?)
513.	Motutara Bluff, north shore of Kawhia Harbour, west coast of Auckland, M., 1884	VI*c*.
514.	Grey-marls, Kekerangu, Marlborough, M., 1884 ...	VI*a*.
215.	Below limestone near Totara Point, south shore of Kawhia Harbour, west coast of Auckland, M., 1884	VI*c*.
516.	Waiheriko River, south side of Kawhia Harbour, west coast of Auckland (Belemnite beds), M., 1884	VIII*b*.

	Locality.	Formation.
517.	Motutara Bluff, north shore of Kawhia Harbour, west coast of Auckland, M., 1884	VI*b*.
518.	Coverham, Clarence Valley, Marlborough, 1884 ...	VI*g*.
519.	Kekerangu Creek, east coast of Marlborough (greensands), M., 1884	VI*c*.
520.	Flag Hill series, south shore of Kawhia Harbour, west coast of Auckland, M., 1884	VIII*c*.
521.	Takatahi, south shore of Kawhia Harbour, west coast of Auckland, M., 1884	VIII*b*.
522.	Putataka beds, north shore of Kawhia Harbour, west coast of Auckland, M., 1884	VIII*b*.
523.	Bastion series, coast between Kawhia Harbour and Albatross Point, west coast of Auckland, M., 1884	IX.
524.	Otapiri series, coast between Kawhia Harbour and Albatross Point, west coast of Auckland, M., 1884	X*a*.
525.	Wairoa series, coast between Kawhia Harbour and Albatross Point, west coast of Auckland, M., 1884	X*b*.
526.	Cretaceo-tertiary, Okoko, Waipa, Kawhia Road, Auckland, P., 1885	VI*b*, *c*.
527.	Shelly limestone, Hauturu, Waipa, Auckland, P., 1885	VI.
528.	Putataka beds, Kohururu, Waingare, south-west of Auckland, P., 1885	VIII*b*.
529.	Taupiri Mine, Waikato River, Auckland, P., 1885 ...	VI*f*.
530.	Beach, Hargreave's Run, opposite Komiti, Kaipara Harbour, Auckland, P., 1885	V.
531.	Strawberry Bay, Wairoa side of Komiti Peninsula, Kaipara Harbour, Auckland, P., 1885	V.
532.	Brown sand and gravel, Te Karaka, south side of Manukau Harbour, Auckland, P., 1885 ...	II.
533.	Slate grit-bed, beach near Howick, Auckland, P., 1885	
534.	Teredo bed, beach near Howick, Auckland, P., 1885	IV.
535.	Calcareous greensand, Onehunga, Auckland, P., 1885	IV.
536.	Teredo bed, Onehunga, Auckland, P., 1885 ...	IV.
537.	Papakura limestone, Slippery Creek, Auckland, P., 1885	VI*e*.
538.	Papakura limestone, Waikohu Creek, Auckland, P., 1885	VI*e*.
539.	Volcanic breccia, coast near Lake Takapuna, Auckland, P., 1885	III*b*.
540.	Orakei Bay, Auckland, P., 1885	VI. (?)
541.	Maungamaungaroa Bridge, Howick, Auckland, P., 1885	VI. (?)
542.	Komiti Point beds (Lower), Kaipara Harbour, Auckland, P., 1885	VI. (?)
543.	Komiti Point beds (Upper) or dirt bed, Kaipara Harbour, Auckland, P., 1885	
544.	Greensands, Pahi, Kaipara Harbour, Auckland, P., 1885	VI*e*.

	Locality.	Formation.
545.	Ruamahunga Ferry (Gladstone), Wairarapa, Wellington, M., 1883	II*d*.
546.	Plant-beds, Clent Hills, Ashburton, Canterbury, M., 1877	VIII*b*.
547.	Graptolite beds, Golden Ridge, Collingwood, Nelson, C., 1882	XV*a*.
548.	Kawau Island, Auckland, C., 1880	IV (?)
549.	Curiosity Shop, Rakaia River, Canterbury, M., 1879	V*b*, VI*b*.
550.	Plants in clay associated with Wharekauri coal, Big Gully, Wharekauri, Waitaki Valley, Otago, M., 1881	III.
551.	Lottery Creek, Sherwood, Amuri District, Nelson, M., 1885	V*a*.
552.	Triassic fossils from high-level river-terrace, Wharekauri, Waitaki Valley, Otago, M., 1881 ...	X.
553.	Lake Te Anau, Southland, Otago, C., 1878 ...	IV*c*.
554.	Heaver's Creek, Kekerangu, east coast of Marlborough, M., 1885	VI*a*.
555.	Waipapa Boat-harbour, Lower Clarence District, east coast of Marlborough, M., 1885	VI*a*.
556.	Sherwood, Lottery Creek, Amuri District, Nelson, M., 1885	IV*c*.
557.	West Branch, Lottery Creek, Amuri District, Nelson, M., 1885	V*a*.
558.	Isolated Hills, Waiau-ua River, Amuri District, Nelson, M., 1885 (western part)	IV*c* or V.
559.	Black-birch Creek, Blairich, Awatere Valley, Marlborough, M., 1884	III*b*.
560.	Plant-beds, Quail Flat, Middle Clarence Valley, Marlborough, M., 1885	VI*f*.
561.	Grey-marls, Shades Creek, Kekerangu, Clarence, east coast of Marlborough, M., 1885	VI*a*.
562.	First gorge (Lower), Lottery Creek, Amuri District, M., 1885	IV.
563.	Flaxbourne River, Cape Campbell District, Marlborough, M., 1884	IV*c*.
564.	Bluff Paddock, Dog Creek, Lyndon Station, Amuri, Nelson, M., 1885	IV*c*. or V.
565.	Central part of Isolated Hills, Waiau, Amuri District, Nelson, M., 1885	IV*b*.
566.	Highfield Ridge, east side of Waiau, Amuri District, Nelson, M., 1885	IV*b*. (?)
567.	Below "Gates," Mason River, Waiau, Amuri, Nelson, M., 1885	IV*b*.
568.	Quail Flat, Middle Clarence Valley, Marlborough, M., 1885	VI*f*.
569.	Weka Pass stone, Seymour River, Middle Clarence Valley, Marlborough, M., 1885	VI*b*.
570.	Amuri beds, Seymour River, Middle Clarence Valley, Marlborough, M., 1885	VII.

	Locality.	Formation.
571.	Quail Flat, Middle Clarence Valley, Marlborough, M., 1885 (freshwater shells)	VI.
572.	Black-grit, Seymour River, Middle Clarence Valley, Marlborough, M., 1885	VI*g*.
573.	Kiwi Range, north side of Mohaka Valley, Napier, M., 1885	IV*b*.
574.	Upper shelly limestone, Scinde Island, Napier, M., 1885	II*a*.
575.	Pohui limestone, Te Whaka Range, south-east side of Mohaka Valley, Napier, M., 1885	III*a*.
576.	Scinde Island, Napier, lowest beds (shelly limestones), M., 1885	II*a*.
577.	Pareora beds, Kakahu River, South Canterbury, P., 1885	IV*b*.
578.	Greensands under Weka Pass stone, Kakahu River, South Canterbury, P., 1885	VI*c*.
579.	Weka Pass stone, Kakahu Valley, South Canterbury, P., 1885	VI*b*.
580.	Rangitaumau Hill, Taueru Road, Masterton, Wairarapa, Wellington, P., 1886 (limestone) ...	III*b*.
581.	Below limestone, Rangitaumau Hill, Taueru Road, Masterton, Wairarapa, Wellington, P., 1886 ...	III*b*.
582.	Blue clays, Urenui, Waitara, Taranaki, P., 1886	II.
583.	Pareora beds, Onairo, Waitara, Taranaki, P., 1886	IV.
584.	Greensands under foraminiferous limestone, Mokau River, south-west of Auckland Provincial District, P., 1886	VI.
585.	Greensands under limestones (Balanus), Birch's, Kaimanawa Range, Wellington, P., 1886 ...	III*b*.
586.	Plant-sandstone under Balanus limestone, Birch's Kaimanawa Range, Wellington, P., 1886 ...	III.
587.	Balanus limestone, Kaimanawa Range, Wellington, P., 1886	III*b*.
588.	Waitotara, Puketapu, Wellington, H., 1886 (bed contains *Ostrea ingens*)	III*b*.
589.	Selwyn Rapids, Selwyn River, Malvern Hills, Canterbury, M., 1886	VI*e*.
590.	Selwyn River, north-east bank below rapids, Malvern Hills, Canterbury, M., 1886	VI*e*.
591.	Railway bridge, near Sheath's Coalmine, Selwyn River, Malvern Hills, Canterbury, M., 1886 ...	VI*e*.
592.	Shag Point, Otago, beach opposite coalmine, and near McIntosh's store, M., 1886	VI*e*.
593.	Mount Puke Iwitai, Lower Shag Valley, Otago, M., 1886	VI*e*.
594.	Little Puke Iwitai, Woolshed Creek, Lower Shag Valley, Otago, M., 1886	VI*e*.
595.	Middle of north side of Moeraki Peninsula, Moeraki District, Otago, M., 1886	VI*e*.

	Locality.	Formation.
596.	Onekakara (Hampden) Beach, North Moeraki Bay, one to two miles north of Hampden, Moeraki, Otago, M., 1886	VI*c*.
597.	Onekakara (Hampden) Beach, one mile south of White Bluff, Moeraka, Otago, M., 1886 ...	VI*e*.
598.	Dunback and Grange (Kitchener's), Shag Valley, Otago, M., 1886	VI*c*.
599.	Guffie's Quarry, Carsphairn, Janet's Peak, Shag Valley, Otago, M., 1886	VI*d*.
600.	Ototara limestone, south side of estuary, Kakanui mouth, Kakanui, Oamaru, Otago, M., 1886 ...	VI*b*.
601.	Dear Park Spur (north-west end of), Bushy Park, south side of Lower Shag Valley, Otago, M., 1886	V*b*.
602.	Seaward Ridge, south side of estuary of Pleasant River, Hawksbury District, Otago, M., 1886 ...	V*b*.
603.	Middle Mountain, source of Pleasant River, Palmerston, Otago, M., 1886	VI*e*.
604.	Muir's Creek, between Harry's Peak and Shag River, Shag Valley, Otago, M., 1886	VI*e*.
605.	Calcareous sandstone, Tumai, Hawksbury District, Otago, M., 1886	VI*b*.
606.	Maheno marls, left bank of Kakanui River, opposite Maheno Railway-station, Oamaru, Otago, M., 1886	VI*b*, *c*.
607.	Anderson's farm, Puketapu, to sea at Goodwood Lagoon, Palmerston, Otago, M., 1886	VI*a*.
608.	Between south end of Mount Royal and sea at Bobby's Head, Palmerston, Otago, M., 1886 ...	VI*a*.
609.	Scrogg's Hill, near Saddle Hill, east side of Taieri Plain, Otago, M., 1886	VI*c*.
610.	Grey-marls, mouth of Seymour River, Middle Clarence Valley, Marlborough, M., 1885 ...	VI*a*.
611.	Grey-marls, Muzzle River, Middle Clarence Valley, Marlborough, M., 1886	VI*a*.
612.	Grey-marls, Dart River, Middle Clarence Valley, Marlborough, M., 1886	VI*a*.
613.	Great Post-miocene conglomerate, Bluff River, Clarence Valley, Marlborough, M., 1885 ...	II.
614.	Black-grit, Coverham, Middle Clarence Valley, Marlborough, M., 1885	VI*f*.
615.	Bluff River (junction with Clarence), Middle Clarence Valley, Marlborough, M., 1886 ...	VII.
616.	Red Hill Creek Bluff, Middle Clarence Valley, Marlborough, M., 1885	VI*g*.
617.	Grey-marls, Bluff River, Middle Clarence Valley, Marlborough, M., 1885	VI*a*.
618.	Weka Pass stone, Bluff River, Middle Clarence Valley, Marlborough, M., 1885	VI*b*.
619.	Kaikoura Peninsula, Marlborough, M., 1886 (Grey marls)	VI*a*.

	Locality.	Formation.
620.	Calcareous sandstone, Puketapu, Palmerston, Otago, M., 1886	VI*b*.
621.	Seacliffs, Bushy Park, south of mouth of Shag River, Otago, M., 1886	IV*c*.
622.	Katiki (Katiki Beach, half a mile north of Shag Point Railway-station), Moeraki, Otago, M., 1886	VI*e*.
623.	White Bluff, between north end of Onekakara Beach and mouth of Otepopo River, Moeraki, Otago, M., 1886	VI*c*. (?)
624.	Hutchinson's Quarry beds, over Ototara limestone, All-day Bay, one mile south of Kakanui mouth, Oamaru, Otago, M., 1886	V*b*.
625.	Pareora beds (=Awamoa beds), All-day Bay, south of Kakanui, Oamaru, Otago, M., 1886	IV*c*.
626.	Junction between Ototara limestone and dirty greensand representing Hutchinson's Quarry beds, All-day Bay, one mile south of Kakanui, Oamaru, M., 1886	V*b*. (?)
627.	Isolated limestone hill, Limekiln Hill, Kakanui Township, Oamaru, Otago, M., 1886	VI*b* or *c*.
628.	Belemnitella beds, Brighton, Saddle Hill, Dunedin, Otago, M., 1886	VI*e*.
629.	Waihola Township, Waihola, Otago, M., 1886 ...	IV. (?)
630.	Concretionary sands overlying Mokau coal, Mokau River, Auckland, P., 1886	VI.
631.	Plant-beds under Shag Point coal, Shag Point, to mouth of the Shag River, M., 1886	VI*f*.
632.	Tertiary beds on coast at Bobby's Head, Palmerston, Otago, M., 1886	IV*c*.
633.	Blue clays, mouth of Kai-iwi River, Wanganui, P., 1886	II*b*.
634.	Shell-beds, mouth of Butler's Creek, Waitotara, P., 1886	II*c*.
635.	Rotella beds, Nukumaru Beach, Waitotara, P., 1886	II*d*.
636.	Nukumaru limestone, Waitotara, P., 1886 ...	II*d*.
637.	Between West Wanganui and Mokihinui, Nelson, H., 1886	VI*f*.
638.	Kaiwaiki quarries, Wanganui Biver, P., 1886 ...	II*d*.
639.	*Ostrea ingens* bed, Waitotara, P., 1886	III*a*.
640.	Blue clays on coast north of Waitotara River, P., 1886	III*a*.
641.	Blue clays, Wairoa Beach, Waitotara, P., 1886 ...	III*a*.
642.	Waihao Bridge, one and a half miles below the Forks, M., 1886	VI*f*.
643.	Amuri limestone, Weka Creek, Weka Pass, M., 1886	VI*d*.
644.	Blue clays, Patea, P., 1886	III*b*.
645.	Blue clays, Pipiriki, Wanganui River, P., 1886 ...	III*b*.
646.	Coal greensands, Mokau River, P., 1886	VI*f*.
647.	Utapu, Upper Wanganui River, P., 1887 ...	III*a*.

	Locality.	Formation.
648.	Otapokiore, Upper Wanganui River, P., 1887 ...	III*b*.
649.	Paparoa Rapids, Upper Wanganui River, P., 1887	V*a*.
650.	Blue clays, Paparoa Rapids, Upper Wanganui River, P., 1887	VI*a*.
651.	Yellow sandy clays, Ongaruhe Valley, P., 1887 ...	VI*a*.
652.	Greensands, Ongaruhe Valley, P., 1887	VI*f*.
653.	Heao Valley, Upper Wanganui, P., 1887 ...	III*a*.
654.	Mangapahoe, Mokau River, P., 1887	VI*f*.
655.	Limestone, near Totoro, Mokau River, P., 1887 ...	VI*b*.
656.	Yellowish clays, Mokau Gorge, near Totoro, P., 1887	VI*a*.
657.	Limestone, Te Ruangaruhe, near Totoro, P., 1887	VI*b*.
658.	Limestone, Wairere Falls, Upper Mokau, P., 1887	VI*b*.
659.	Limestone, Pipiriki, Upper Wanganui. P., 1887 ...	III*a*.
660.	Limestone at Caves, near Mangaio, Upper Wanganui, P., 1887	III*a*.
661.	Secondary rocks, Awakino Valley, P., 1887 ...	VIII*a*.(?)
662.	Limestone, Tata Island, Nelson, H., 1887 ...	III*a*.
663.	Limestone, Awakino Valley, P., 1887	VI*b*.
664.	Limestone on range, head of Mangatawa, Mokau River, P., 1887	VI*b*.
665.	Shales, one and a half miles below Mataura Falls, Southland, P., 1887	VIII*a*.
666.	Plant-beds, below upper conglomerate, at waterfall, head of left branch of Lora, Hokonui Hills, P., 1887	VIII*a*.
667.	Lower plant-beds, Dunsdale, Hokonui Hills, P., 1887	VIII*a*.
668.	Plant-beds, Hedgehope, Hokonui Hills, P., 1887	VIII*a*.
669.	Plant-beds, McRae's, Makarewa, Hokonui Hills, P., 1887	VIII*a*.
670.	Plant-beds, Coal Creek, Otapiri Gorge, Hokonui Hills, P., 1887	VIII*a*.
671.	Plant-beds, top of Flag Hill, Hokonui Hills, P., 1887	VIII*a*.
672.	Plant-beds, Otapiri Gorge, near Conical Hill, P., 1887	VIII*a*.
673.	Highest Spirifer grit, Otapiri Gorge, P., 1887 ...	VIII*b*.
674.	Tachylite breccias, Oamaru Breakwater, P., 1886	V*a*.
675.	Waireka tufas, Teaneraki, Oamaru, P., 1886 ...	VI*c*.
676.	Coal greensands, Livingstone line, Oamaru, P., 1886	VI*f*.
677.	Plant-beds, South Head, Waikawa, P., 1886 ...	VIII*a*.
678.	Plant-cherts, Landslip Hill, Waipahi, Otago, P., 1886	VI*f*.
679.	Waihou Bay, Bay of Plenty, M., 1887	II*c*.
680.	Mohaka crossing, Te Purutu Creek, Napier, M., 1887	III*b*.
681.	Pumice-sands, Kaiwaka Station, Esk Valley, Napier, M., 1886	II*c*.
682.	Shelly limestone, Raukokore, Bay of Plenty, M., 1887	III*a*.

Locality.	Formation.
683. Esk River, Napier, M., 1886	IIc.
684. Akuakua, Waipiro Bay, east coast of Auckland, M., 1887	IVc.
685. Akuakua, Venus beds, east coast of Auckland, M., 1887	IVc.
686. Waipiro Creek, east coast of Auckland, M., 1887 ...	IVc.
687. Pumice-sands, mouth of Mohaka River, M., 1887...	IIc.
688. Secondary beds, Awanui, M., 1887	VIf.
689. Raised beach, Mahia Peninsula, M., 1887 ...	Id.
690. Clays under Petane limestone, Petane, M., 1887 ...	IId.
691. Petane limestone, Petane, M., 1887	IIa.
692. Secondary rocks, Waipawa Gorge, M., 1886 ...	VIe.
693. Under Te Aute limestone, south-east corner Ruataniwha Plain, Hawke's Bay, M., 1886 ...	IIIb.
694. South-east slopes of Mount Vernon, Napier, M., 1886	IIIe.
695. Tertiary beds, Motutapu Island, P., 1887 ...	IVc.
696. Gibson's, Te Ope Creek, Pahi, Kaipara, P., 1887 ...	VIf. (?)
697. Volcanic grit, Cheltenham Beach, North Shore, Auckland, P., 1887	IVc.
698. Greensands below limestone, Colbeck's Landing, Pahi, Kaipara, P., 1887	VIf.
699. Limestone, Colbeck's, Pahi, P., 1887	VIe.
700. Beds below hydraulic limestone, Batley, Kaipara, P., 1887	VId.
701. Parnell grit, Judge's Bay, Auckland, P., 1887 ...	IVc.
702. Lower limestone, Scinde Island, M., 1887 ...	IIIa.
703. Te Whaka Range, west of Pohui, Napier, M., 1887	IIa.
704. Mahia Township, Mahia Peninsula, Hawke's Bay, Wairoa County, M., 1887	VIa.
705. Plant and shell-beds (pumiceous), Te Kaha, Bay of Plenty, Wakatane County, M., 1887	Id.
706. Clyde, Wairoa River, Hawke's Bay, Wairoa County, M., 1887	IId.
707. Outlet of Waikaremoana Lake, Wairoa Valley, East Coast, Wairoa County, M., 1887	V.
708. Limestone east of Takapau, Ruataniwha Plain, Hawke's Bay, Waipawa County, M., 1887 ...	IIIa.
709. Under Te Aute limestone, Cape Kidnappers section, Hawke's Bay County, Hill, 1887	IIIa.
710. Limestone, twelve miles north-west of Ormond, Gisborne, Opotiki Road, Cook County, M., 1887 ...	IIb.
711. Pumice-sands, Gisborne, Opotiki Road, two miles west of Waipaoa River, Napier, Taupo Road, Cook County, M., 1887	IIb.
712. Lower fossiliferous bed, Petane series, between Kawaka Cutting and Rangimapapa, Hawke's Bay County, M., 1887	IId.
713. South-west of Napier Harbour (specimens of Retropora, &c.), Hawke's Bay County, Hamilton, 1886	IIb.

	Locality.	Formation.
714.	Tertiary beds, Upper Mata River, Waipu Valley, East Cape District, Cook County, M., 1887 ...	IV*c*.
715.	Under Amuri limestone, Upper Mata River, Waipu Valley, East Cape District, Cook County, M., 1887	VI*e*.
716.	Creek between Taitai and Aorangi, Mata River, Waiapu Valley, Cook County, M., 1887... ...	VI*e*.
717.	Beds between Petane limestone, north-east side of Lower Esk, Petane, M., 1886	II*b*.
718.	Pleistocene beds, Cape Kidnappers section, Hawke's Bay County, M., 1886	I*d*.
719.	First limestone bluff north of Petane (along the coast), clay overlying, Hawke's Bay County, M., 1887	II*b*.
720.	Upper band of Petane limestone, between Lower Esk and Petane Hotel (Veller's), Hawke's Bay County, M., 1886	II*b*.
721.	Plant-beds, pumice-sands, Kaiwaka Station, Esk Valley, Pliocene, Hawke's Bay County, M., 1886	II*b*.
722.	Waikare, Taheki River, six miles south-east of Waikaremoana Lake, Hawke's Bay, Wairoa County, Hamilton, 1885	III*b*.
723.	Upper calcareous band, Mount Brown, Waipara, Ashley County, P., 1887	V*a*.
724.	Lower calcareous band, Mount Brown, Waipara, Ashley County, P., 1887	V*a*.
725.	Coal-shales, north end of Doctor's Gorge, Waipara River, Ashley County, P., 1887	VI*f*.
726.	Coal-shales, Upper Wangapeka, four miles from saddle, Waimea County, P., 1888	VI*f*.
727.	Coal-shales, Owen River, Inangahua County, P., 1888	VI*f*.
728.	Waitangi River, opposite Waimate, Bay of Islands County, M., 1888	VI*e*.
729.	East branch of Waihou River, near Okiahau, Bay of Islands, Hokianga County, M., 1888	VI*e*.
730.	The Narrows, Hokianga River, North Auckland District, Hokianga County, M., 1888	VI*f*.
731.	Cliffs north end of Cheltenham Beach, North Shore, Auckland, Waitemata County, M., 1887 ...	III.
732.	Pahi greensands, Township Kaipara, Auckland, Hobson County, M., 1887	VI*e*.
733.	Orbitulite limestone, Hokianga, South Head, Auckland North, Hokianga County, M., 1888 ...	III.
734.	Amuri series, Pararoa River, Kaipara, Auckland, Hobson County, M., 1888	VII.
735.	Kawakawa Coal-mine, Bay of Islands County, M., 1888	VI*e*.
736.	Collection of Petane and Napier fossils, Hawke's Bay County, Hamilton, 1884...	II*b*.
737.	*Ostrea ingens* limestone, Te Aute, Napier, Waipawa County, P., 1888	III*a*.

No.	Locality.	Formation.
738.	From greensands, junction of Aorere River and Boulder Creek, Collingwood County, P., 1889 ...	VI*e*.
739.	From greensands on coast between Anatori and Big River, Collingwood, Collingwood County, P., 1889	VI*e*.
740.	Graptolites, from Golden Ridge Claim, Taitapu, Collingwood County, P., 1889	XV*a*.
741.	From Cretaceo-tertiary beds, Gladstone and Middlehurst Runs and Upper Awatere, Marlborough County, M., 1888	VI*c*.
742.	Dirty greensands, Puponga Point, Collingwood County, P., 1889	VI*e*.
743.	Ferruginous sandstone, Puponga Point, Collingwood County, P., 1889	V*f*.
744.	From crystalline limestone, Sparrow's, Takaka, Collingwood County, P., 1889...	VI.(?)
745.	From blue clays on coast, near Onakaka, Collingwood County, P., 1889	VI*a*.
746.	From cave limestone, Cave Hill, Collingwood County, P., 1889	VI*b*
747.	From greensands, Riley's Creek, Pakawau, Collingwood County, P., 1889	VI*c*
748.	Limestone above shell-bed over coal, Kawakawa Coal-mine, Bay of Islands County, M., 1884 ...	VI*f*.
749.	Cliffs at mouth of Ruamahanga River, Palliser Bay, Wellington, Wairarapa East County, M., 1882 ...	II*b*.
750.	Cone-in-cone limestone, Totara, Whangaroa, North Auckland, Mongonui County, M., 1890	VI*c*.
751.	Greensands east of Pakaraka, Bay of Islands County, M., 1890	VI*c*.
752.	Welshman's Gully, Switzers, Otago, Southland County, M., 1890	V.
753.	Greensands from deep shaft, Naseby, Otago, Maniototo, H., 1890...	VI*e*.
754.	Malvern Hills (coal-beds), Canterbury, Selwyn County, H., 1890	VI*e*.
755.	Shepherd's, Kaeo River, Mongonui County, M., 1890	VI.
756.	Orepuki Hill, behind diggings, Southland, H., 1891	IV*b*.
757.	Cobden limestone quarries at Greymouth (?), 1891	VI*b*.
758.	Nummulitic limestone, Greymouth (?), 1891 ...	V*e*.
759.	Castle Hill shaft, Kaitangata Coalfield, H., 1891	VI*e*.
760.	Measley Beach, Otago, H., 1891	VI*e*.
761.	Middle Waipara saurian beds, Canterbury, M., 1891	VI*e*.
762.	Middle Waipara coal-beds, Canterbury, M., 1891...	VI*f*.
763.	Malvern Hill coal-beds, MacIlwraith's coal-mine, M., 1891	VI*f*.
764.	Coast-line between Pleasant River and Waikouaiti Bay, Otago, H., 1891	VI.

10

INDEX TO FOSSILIFEROUS LOCALITIES ACCORDING TO THE COUNTIES IN WHICH THEY OCCUR.

AKAROA COUNTY.

THIS is almost wholly volcanic, and, the rocks being lava-streams or ash-beds, which so far as known are of purely terrestrial origin, they present a very unpromising field for the fossil-collector. Land shells and plants might be found in the interbedded soils of more ancient date. Associated with moa bones they occur in the slope deposits, silts, sand-dunes, and swamps of recent date. The famous moa-bone caves near Sumner are in this county.

The oldest rocks within the county are of Carboniferous or Devonian age, and appear over a small area on Gebbie's Pass, where also there is a limited outcrop of rocks belonging to the Cretaceo-tertiary or to the lower greensand formation.

The volcanic region of Banks Peninsula is thus known to belong to a period of later date than the coal-formation of the Malvern Hills and the coal-formation generally on both coasts of the South Island. When vulcaneity ceased over this region there are no means of exactly determining, but it may be taken for granted that there has been no activity since Upper Miocene times.

AMURI COUNTY.

In this county the rocks belong to two great groups of strata. The first, of Old Secondary or younger Palæozoic age, forms exclusively the western and northern parts of the county, and appears as isolated ranges in the southern and eastern parts. The second group consists mainly of Tertiary strata developed round the margins of the great Hurunui-Waiau old lake-basin, and beyond this to east as far as Hawkeswood Station. Young Secondary and Cretaceo-tertiary rocks are developed to a limited extent among the Mendip Hills and along the right bank of the Conway River, and, it may be, also at one or two places along the north-western side of the Hurunui-Waiau Plain. Volcanic rocks of Tertiary date appear at Lyndon Station and in Lottery Creek, and form a distinct horizon of lava floes and fossiliferous tufas, thence extending north-east along the Mason River and the Whale's Back Range to the Conway River, and in a south-west direction to the Pahau River. Fossils have been collected at the following places, indicated by the localities, number, and (within brackets) the ages to which the rocks collected from are or have been referred: Nos. 36 (VI*d*), 110 (V*a*), 216 (IV*b*), 232 (IV*b*), 304 (V*a*), 305 (V*a*), 306 (V*a*), 315 (VI.), 321 (IV*d*), 551 (V*a*), 556 (IV*c*), 557 (V*a*), 558 (IV*c* or V.), 562 (IV.), 564 (IV*c* or V.), 565 (IV*b*), 566 (IV*b*?), 567 (IV*b*).

ASHBURTON COUNTY.

The oldest fossiliferous rocks within the county form the western slopes of Mount Potts in the Upper Rangitata Valley. The age of these has been variously determined, and at different times has formed matter for discussion. The late Sir Julius von Haast to the last regarded them as of Lower Carboniferous or Devonian date, and the equivalents of the Clent Hills plant-beds. Professor Hutton speaks of them as being of Triassic date, but by the Geological Survey they have hitherto been regarded as of Permian age. The plant-remains from Mount Potts and the Clent Hills, examined by Baron von Ettingshausen, led him to the conclusion that the beds at both places are of Triassic age, but there can be little doubt that the Clent Hills beds are younger than the shell beds of Mount Potts. The Mount Potts beds, besides an abundance of Brachiopooda, abound in reptilian remains, the true character of which has not yet been exactly determined, but from the nature of the vertebræ it would appear that these remains have some affinity to the genus Ichthyosaurus. The vertebræ are much constricted in length and the ribs flattened, and hatchet-shaped, but not divided at the articulation. Some of the vertebræ are of enormous size, as much as 15in. in diameter. One fine specimen not yet collected shows a connected series of sixteen vertebræ and thirty-two ribs of the character described. The centra of the vertebræ are 4½in. in diameter, and the ribs about 3ft. 6in. in length. The Clent Hills plant-beds are distant from the Mount Potts shell-beds about fifteen miles, and are of Oolitic or Liassic date, and agree as to the species they contain with the fern-beds of the Malvern Hills in Selwyn County, the fern-beds of Waikato South Head, Raglan County, and of Owake Creek and Waikawa, both in Clutha County.

The younger series of rocks where fossiliferous are of Cretaceo-tertiary date, except, it may be, some beds near Lake Heron, which are probably of Miocene age. The Mount Somers limestone, which is a coralline calcareous sandstone, is the great source of fossils in this younger series of rocks. The following are the numbers of the localities collected from: Nos. 102 (VI*e*), 103 (V*a*), 104 (V*a*), 136 (XI*b*), 325 (III*b*?), 326 (V., VI.), 401 (XI*a*), 402 (XI*a*), 405 (VIII*a*), 474 (V*a*), 546 (VIII*b*).

ASHLEY COUNTY.

The western and more mountainous parts of this county have been only partially explored geologically. In this part there are a few outliers of Tertiary or Cretaceo-tertiary beds which have not been examined except by Von Haast, and he does not appear to have made fossil collections therefrom. The extreme western parts of the district are formed of Carboniferous strata belonging to the Maitai series, which again show along the front range of higher mountains from Mount Oxford to Mount Grey, and probably further to the north-east in Pendle Hill, near the mouth of the Hurunui River.

Old Secondary rocks of Triassic and Rhætic age are developed to the westward of Mount Grey and Mount Thomas Range as far as the Ashley Gorge and Mount Oxford, and probably extend south-west in this direction into Selwyn County. These rocks are peculiar in their lithological characters, and of great interest on account of the presence in them of distinctively Triassic fossils, including *Monotis salinaria* and *Mytilus problematicus*, which indicate that a large part of the mountainous interior district of Canterbury is probably formed of Lower Mesozoic rocks.

The rocks of Upper Mesozoic and Cretaceo-tertiary age, developed in the Middle and Upper Waipara, and thence extending east and north-east to the northern boundary of the district, and south-west along the lower flanks of the front ranges to the Eyre River, west of Oxford, are of very great interest on account of the saurian remains which they have yielded. The Tertiary strata of the district are confined to the Waipara Valley and the north-east part of the district, and are of great interest in the Dean's Range between the Waipara and the Weka Pass, in the Waikari Valley and at Motunau. The youngest fossiliferous strata yielding marine forms are found at Motunau, and are considered to be of Pleistocene age, most of the species found in the younger beds at that place being still living in the neighbouring sea. The following are the localities, numbers, and ages of the beds where collections have been made: Nos. 66 (V*a*), 71 (VI*a*), 74 (VI*b*), 149 (VI*f*), 150 (VI*a*), 151 (X*b*), 152 (VI*f*), 159 (IV*b*), 160 (IV*b*), 218 (IV*b*), 219 (II*a*), 228 (IV*b*), 233 (IV*b*) 277 (VI*f*), 295 (VI*f*), 313 (V*a*), 460 (X*a*), 503 (VI*c*), 504 (IV*c*), 643 (VI*d*), 723 (V*a*), 724 (V*a*), 725 (VI*f*).

BAY OF ISLANDS COUNTY.

The north and eastern parts of this county are formed of Palæozoic strata, at many places overflowed by volcanic rocks of quite a modern date. Towards the south-east lies the Puhipuhi Forest and the silver-mines lately discovered and in course of development. Westward of Ruapekapeka Hill stretches an extensive area of Cretaceo-tertiary coal-bearing rocks, which are continuous from Kawakawa to the south-western limits of the county. Unfortunately, workable seams of coal have yet been found only in the neighbourhood of Kawakawa. During the course of explorations for coal, fossils have been discovered and collected at several places. Generally, however, it cannot be said that the rocks of the district abound in fossils, and apparently there are no Tertiary fossiliferous rocks within the county. The localities and ages of the beds collected from are given below: No. 417 (VI*f*), 454 (VI*f*), 728 (VI*e*), 729 (VI*e*), 735 (VI*f*), 748 (VI*f*), 751 (VI*e*).

BRUCE COUNTY.

The northern portion of this is mainly formed of schistose rock, here and there overspread by quartzose gravels and breccia-conglomerate rocks, which are at many places auriferous. In the central and eastern parts the fundamental rock is a semi-metamorphic or unaltered Palæozoic formation, on which there lie extensive areas of younger Cretaceo-tertiary rocks, and rocks of later date. Volcanic rocks break through these latter near the Waihola Gorge, and within Waihola Township. A remarkable feature of this part is the extension, south-west across the Taieri River, of the Henley breccias, forming a range of hills to the east of Waihola Lake, and continued till abreast of Waihola Gorge, where they are terminated in a hill of considerable height (1,200ft.), overlooking the Tokomairiro

Plain. Towards the base the breccias are fossiliferous, and probably of Miocene age. The valuable Kaitangata Coalfield forms the southern part of the county, and is nearly connected with other coal-bearing areas stretching along the coast-line or bordering the Tokomairiro and Waihola Plains. Fossils have been collected at several places chiefly for the purpose of determining the age of the coal-bearing strata and their identity, or otherwise, with the coal-bearing areas within the adjoining Taieri County. Until very lately no marine fossils have been found within the western and more productive part of the Kaitangata Coalfield. Such have now been found in the new Castle Hill shaft, and these have served to correlate several localities as belonging to one horizon, which could not before be determined, and at the same time they show that the Kaitangata coal-strata underlie the calcareous rocks of Waihola Gorge and Millbank, the equivalent of the Ototara building-stone, and thus prove that the age of the Kaitangata and Green Island Coalfields is the same. The localities and ages of the beds collected from are: No. 40 (VI*b*), 41 (VI*e*), 280 (VI*e*), 629 (IV.), 759 (VI*e*), 760 (VI*e*).

BULLER COUNTY.

The older rocks of this area are to a large extent of a metamorphic character, consisting of granites, gneissic, and schistose rocks, but there are also considerable areas of unaltered, or but slightly altered, slates and sandstones of Devonian and Carboniferous age: the latter, represented by the Maitai series, is the chief auriferous formation of this and the adjoining Inangahua County. In one locality are doubtfully identified Middle Secondary rocks present. These occur on the banks of the Buller River, opposite Hughie's, but, as no Middle or Old Secondary rocks are elsewhere found on the west coast of the South Island, it is likely that these will yet prove to be in connection with the coal-formation of Okarika Creek, which is not far distant.

The younger formations are of Cretaceo-tertiary and of Miocene age. The Cretaceo-tertiary or coal formation extends, though not uninterruptedly, along the whole of the coast-line, and between the Wanganui and Buller Rivers stretches inland to form the Mokihinui, Mount Rochford, and Buller Coalfields. Except in the calcareous higher members of the series, the Cretaceo-tertiary rocks are not abundantly fossiliferous, but fossil shells have been collected at a few places in the Mokihinui and Mount Rochford areas from the grits and calcareous mudstones overlying the coal, and a few obscure shells have been obtained from the Cape Foulwind limestone. South of Cape Foulwind the calcareous members of the series are richly fossiliferous.

The Miocene fossiliferous strata are developed to a limited extent near the mouth of the Mokihinui River, and largely inland of the coast-line between the Buller River and the south boundary of the county west of the Paparoa Mountains. The localities, and the formations to which the beds belong, are here indicated: No. 28 (VI*f*), 31 (VI*f*), 33 (VI*e*), 34 (VI*c*), 44 (IV*b*), 45 (VI*f*), 46 (VI*b*), 55 (VI*a*), 124 (VI*e*), 125 (IV*b*), 274 (VI*f*), 278 (VI*c*), 281 (VI*f*), 411 (VI*f* or *g*), 637 (VI*f*).

CHEVIOT COUNTY.

Near the mouth of the Hurunui River there is a small patch of rocks belonging to the Maitai series, and, consequently, referable to the Carboniferous era.

The coast-range to the north-east of the Jed River, and the Lawery Peaks forming the western limits of the county, are formed of Old Secondary rocks, probably of Triassic age. Young Secondary Cretaceo-tertiary rocks belonging to Formations VI. and VII. are found along the inner slopes of the coast-range and along the Jed River, and Tertiary strata of Miocene date are also found in the low grounds of the central areas. Much interest attaches to the rocks of Cretaceo-tertiary age along the lower course of the Jed River on account of the discovery of a gigantic specimen of *Mauisaurus haastii* (Hector), the bones of which, unlike similar remains in the Middle Waipara and at Amuri Bluff, were not found in hard concretionary boulders, but loosely embedded in soft greensand strata. The specimen in question was collected by the late Sir Julius von Haast, and is now preserved in the Colonial Museum at Wellington. The localities, numbers, and ages of the beds where collections have been made follow: No. 502 (VI*e*), 505 (III*b* or IV).

CLUTHA COUNTY.

The northern prolongation of this area along the west side of the Upper Pomahaka is formed of schistose rocks similar to those of the central goldfields of Otago. South of the Waipahi the fundamental rocks are unaltered sediments of Palæozoic and Secondary ages. The oldest of these are at least of Carboniferous age, and belong to the Maitai series of the Geological Survey classification. On these rest the Permian rocks of the district, which from Nugget Point stretch along the eastern base of the Kaihiku Range to Popotuna, and thence, bending to the north-west, form the northern scarp of the hilly country between the Lower Mataura and Molyneux Rivers, and reach the western boundary of the county opposite the Township of Gore. These beds are abundantly fossiliferous all along the line described, and have been collected from at several places along the eastern slopes of the Kaihiku Range. The most remarkable and characteristic fossil is a species of Spiriferina, the Trigonotreta of King, which, with widely-extended and dagger-pointed valves, at first sight resembles closely some forms of Devonian Spiriferidæ. In due sequence on these Permian rocks follow Triassic, Rhætic, and Liassic strata, of which a very large development occurs between the Kaihiku Range and the Mataura River below Gore. These also contain rich and varied fossil faunas, and also at many places fossil plants. Jurassic rocks next succeed, and have their principal development in the western part of the district opposite the Township of Mataura. The upper beds are chiefly estuarine, and yield a rich fossil flora at Mataura Falls and at Waikawa within the boundaries of Southland County, and at Owake Creek in this. Cretaceo-tertiary and Tertiary rocks are confined to the Pomahaka and Waipahi Valleys, and Landslip Hill, the higher part of which yield many finely-preserved fossil plants preserved in a species of chert. The localities, numbers, and ages of the beds collected from within Clutha County are: Nos. 16 (XI*b*), 17 (XI*b*), 18 (XI*b*), 19 (IX*a*), 20 (IX*a*), 21 (IX*a*), 75 (XI.), 131 (XI.), 133 (X*a*), 134 (XI*a*), 135 (X*c*), 146 (IX*a*), 147 (IX*a*), 148 (IX*a*), 161 (X*a*), 329 (IV*b*), 408 (VIII*a*), 420 (IV*b*), 472 (IX*a*), 678 (IV*b*). [*Note.*—It may here be explained that there has been great difficulty in deciding as to the age of the Landslip Hill plant-beds. The plants themselves no doubt indicate the horizon of the Cretaceo-tertiary coal-measures, but not far distant from Landslip Hill and apparently belonging to the same sequence of strata are shell-beds that have often been, and by some still are, regarded as belonging to the Miocene period. Hence sometimes the Landslip Hill plant-beds have been referred to Formation IV. and sometimes to Formation VI.]

COLLINGWOOD COUNTY.

In this county occur Lower Silurian rocks, yielding an abundance of graptolites, which are not only the oldest fossiliferous strata of this district, but of all New Zealand. There are also Cretaceo-tertiary and Tertiary fossiliferous strata, but there appears to be an absence of Middle Secondary fossiliferous strata. Such strata, if ever present in the district, have been removed or altered by metamorphic action or the intrusion of igneous material, and cannot longer be traced. The Carboniferous formation is represented, but has not yet been proved fossiliferous. The sections along the West Coast, from Cape Farewell southward, show the presence of Tertiary rocks resting on the Cretaceo-tertiary formation, and both are richly fossiliferous. On the eastern side of the main water-parting the coal-bearing rocks of Pakawau yield fossil plants that are of great interest, and are supposed to indicate a cretaceous age for the beds in which they occur. The calcareous rocks of the "Castles" further inland yield a fauna of a more Tertiary aspect, but resting on the quartz-grit, and passing insensibly into it; the fossils from the Castles should, according to the view that the quartz-grits belong to the coal-bearing series, be regarded as belonging to one of the upper divisions of the Cretaceo-tertiary series. The same calcareous rocks, richly fossiliferous, are found along both sides of, and at places filling, the Takaka Valley. The locations and ages of the beds collected from are: Nos. 47 (V*a*), 230 (V*a*), 261 (V*a*), 296 (V*a*), 302 (III.), 410 (VI*g*), 431 (XV*u*), 547 (XV*a*), 662 (III*a*), 738 (VI*e*), 739 (VI*e*), 470 (XV*a*), 742 (VI*e*), 743 (VI*f*), 744 (V*a*), 745 (VI*e*), 746 (V*a*), 747 (VI*e*).

COOK COUNTY.

Old Secondary and Palæozoic rocks run north-east through the length of this area and form the geological axis of the district, but only rarely form the water-parting between the East Coast and the Bay of Plenty. In such rocks no fossils have yet been found. The next succeeding formation present in the district has been referred to the Lower Greensand formation, but, as this is usually closed by a representative of the Cretaceo-tertiary greensands or the Amuri limestone, these being absent there arises the difficulty in the reference of these beds, whether to Formation

VI. or VII., and, in the case of the lowest rocks of this sequence seen in the Mata Gorge and along the south-east base of Hikurangi Mountain, as to whether the lowest beds should not be referred to the higher part of Formation VIII.

Tertiary beds are found near Cape Runaway, at Hicks Bay, and at places along the coast from East Cape to Poverty Bay, and between Poverty Bay and Waipiro extend to considerable distances inland along the valleys of the Mata (Upper Waiapu and Waipoa Rivers). Very recent deposits are found in the vicinity of the Town of Gisborne, containing recent shells and footprints of the moa. The localities and ages of the beds collected from are as follow: Nos. 60 (VI*a*), 65 (VI*a*), 68 (IV*b*), 69 (IV*b*), 70 (IV*b*), 72 (VI*d*), 73 (VI*d*), 88 (VII.), 89 (VII.), 90 (VI*d*), 111 (VI*e*). 127 (VII.) 202 (I*c*), 203 (II*a*), 204 (II*b*), 212 (II*a*), 223 (IV*b*), 249 (IV*b*), 263 (IV*b*), 287 (VI*a*), 307 (VI*a*), 328 (IV*b*), 684 (IV*c*), 685 (IV*c*) 686 (IV*c*), 688 (VI*f*), 710 (II*b*), 711 (II*b*), 714 (IV*c*), 715 (VI*e*), 716 (VI*e*).

COROMANDEL COUNTY.

Palæozoic sandstone and slates underlie the auriferous tuffs and overlying volcanic rocks of the Cape Colville peninsula, but in none of these rocks have fossils yet been found. There is, however, near Cabbage Bay a small area over which sedimentary rocks belonging to the Cretaceo-tertiary series are found. These apparently underlie volcanic tuffs, but they are of little value for the determination of the age of the auriferous rocks of the peninsula, which are distant from the locality. All that can be said is that the tufaceous rocks are younger than these fossiliferous strata, but whether belonging to the same or to a younger and totally different period has yet to be finally determined. Locality No. 292 (age?).

EAST TAUPO COUNTY.

A portion of the Kaimanawa Range included in this shows sub-metamorphic rocks at the surface; all the rest is of volcanic origin; and as yet nowhere within the boundaries of the county have fossils of any kind been found.

EDEN COUNTY.

The surface of this is at most places formed of volcanic rocks, and it is only in sections exposed along the shore-line of the Waitemata and Tamaki, inlets of Hauraki Gulf, that fossiliferous strata are exposed. Orakei Bay is the principal locality for fossils, and at that place the beds are referred to the Grey-marls of the Cretaceo-tertiary series. The localities, numbers, and ages of the beds are as follow: Nos. 297 (VI*a*), 535 (IV.), 536 (IV.), 540 (VI.?), 701 (IV*e*).

FIORD COUNTY.

This area is accupied chiefly by crystalline schists, and it is only in the southern portion of this that plant-fossils have been found in Cretaceo-tertiary coal-bearing rocks that form part of Coal Island and also of the mainland towards Puysegur Point.

GERALDINE COUNTY.

The fossiliferous rocks of this area, so far as known, are confined to the lower ranges and downs east of the Mackenzie Country. The oldest fossiliferous rocks are probably of Triassic age. Triassic fossils are found in the gravels of the Waitaki River bed below the Hakateramea junction, but not above that point, and the assumption is that the fossiliferous boulders have been derived from the Canterbury side of the valley, and from the ranges bounding the Mackenzie Country on the east side. These ranges lie within Waimate County, but the formation would also extend into Geraldine County. Cretaceo-tertiary and Tertiary rocks, richly fossiliferous, are largely developed in the eastern parts of the district. The Pareora River gives name to a series of Miocene rocks widely distributed over New Zealand. The coal-bearing series and the Upper Calcareous members of the formation have been collected chiefly in the neighbourhood of the Kakahu River. The localities and ages of the beds collected from are indicated as follow: Nos. 56 (VI*f*), 162 (VI*b*), 163 (VI*e*), 164 (VI*f*), 458 (IV*b*), 577 (IV*b*), 578 (VI*e*), 579 (VI*b*).

GREY COUNTY.

The interior eastern part of Grey County is, geologically, but little known except along the banks of the Teremakau River, and a similar line of travel along the northern boundary—viz., from Reefton to the East Coast by way of the Cannibal Gorge. The fossiliferous rocks of the district are confined to the lower Grey Valley, the valley of the Ahaura, and the coastward slopes of the mountains north and south of Greymouth. In these areas both Tertiary and Cretaceo-tertiary rocks are present. The latter form the Grey Coalfield, and here from the lower beds the plant-remains collected are supposed to indicate a Cretaceous age; but the shell-beds that on the banks of the Grey and at the Nine-mile and Ten-mile Creeks, north of Greymouth, closely overlie the coal-measures, do not contain a fauna of a pronouncedly Cretaceous type. On the contrary, they generally have a decidedly Tertiary aspect, so that the evidence for the Cretaceous age of this coalfield is less pronounced than for many of the so-called Tertiary coalfields on the east coast of the Island. The sequence overlying the coal is closed by the Cobden limestone, which has been much quarried near Greymouth. From the quarries and their neighbourhood large collections of fossils have been made. Tertiary foraminiferous limestones overlie the Cobden limestone, and these latter are followed by sandy clays of Miocene date in this district, which close the Tertiary sequence. Heavy deposits of coarse gravel form hills between Greymouth and Marsden and at places inland. These, in the process of being worked for gold, occasionally yield moa bones, but contain no marine fossils. The localities, numbers, and ages of the beds collected from within this area are as follow: Nos. 27 (VI*f*), 29 (VI*f*, *g*), 32 (VI*f*), 35 (VI*d*), 58 (VI*b*), 59 (VI*b*), 61 (V*c*), 64 (VI*b*), 210 (III*c*), 211 (III*d*), 266 (VI*b*), 286 (VI*b*), 290 (V*c*), 412 (VI*f*), 497 (IV*c*), 509 (VI*f*).

HAWKE'S BAY COUNTY.

The western part of this is formed of Old Secondary and Palæozoic rocks, on the eastern slopes of which the next succeeding rock is generally of Pliocene age. Miocene-tertiary rocks very rarely occur along the westerly limit of the younger sequence of rocks. At one place in the bed of the Waipunga River fossiliferous rocks of modern age are deeply involved as a narrow exposure among the older rocks of that part of the district. The Young Secondary and Cretaceo-tertiary rocks are confined to the southern, central, and coastward parts of the district. Isolated outcrops of the older rocks occur in this part also, but only at a few places. The Secondary rocks yield Ammonites and Inoceramus, but Belemnites have not yet been collected. The older of the Tertiary rocks are developed in the neighbourhood of Cape Kidnappers, and again in the northern part of the country, as stated. The Te Aute limestone is developed in the southern part, while the Petane limestone and underlying clays and pumice-sands, conglomerates, &c., have an enormous development in the north-east part. Everywhere these beds are richly fossiliferous, and at many places they have been extensively collected from. The rocks forming Scinde Island, according to the Geological Survey, belong to this Petane series of Young Pliocene strata, but some geologists have contended that the lower beds in Scinde Island are of Miocene date. In the Maungahararu Range the upper limestone attains a height of 4,000ft. above the sea, and the whole mountain mass is formed of Tertiary strata, no old rocks being found on the coastward side of the Mohaka valley. Recent and Pleistocene gravels, with beds of pumice-sand, are largely developed along the shore and inland of the southern side of Hawke's Bay. These yield recent shells and the flora of the neighbouring land only. The localities collected from, and the ages of the beds, are here given: Nos. 77 (II*c*), 28 (I*d*), 79 (II*a*), 80 (II*a*), 83 (VII.), 116 (VI*a*), 120 (II*b*), 122 (II*b*), 188 (II*c*), 189 (III*b*), 190 (III*b*), 191 (II*a*), 192 (II*a*), 193 (II*b*), 194 (II*c*), 217 (II*a*–III*b*), 220 (II*a*), 221 (II*b*), 222 (II*c*), 231 (II*b*), 330 (III*e*), 573 (IV*b*), 574 (II*a*), 575 (III*a*), 576 (II*a*), 585 (III*b*), 586 (III.), 587 (III*b*), 680 (III*b*), 709 (III*a*), 712 (II*d*), 713 (II*b*), 717 (II*b*), 718 (I*d*), 719 (II*b*), 720 (II*b*), 721 (II*b*).

HOBSON COUNTY.

A few isolated areas of old rock of Carboniferous or Devonian age make their appearance within this county, but Young Secondary and Cretaceo-tertiary rocks may be considered as the prevailing formations underlying the more recent volcanic deposits of Tertiary age. Between the Kaipara inlet and the sea large areas of recently-deposited beds of sand and lignite are found. The most interesting localities for fossils are at Pahi and Paparoa. The relation which the Upper Secondary rocks bear to the greensands corresponding to the cover of the coal at Kawakawa is still unsolved, and involves questions of great economic importance. The localities and ages of the beds collected from are here indicated: Nos. 466 (VI*a*), 467 (VII.), 544 (VI*e*), 732 (VI*e*), 734 (VII.).

HOKIANGA COUNTY.

Carboniferous or Devonian rocks form a rugged mountain-range on the south side of Hokianga Inlet or River, as it is usually called. The Maungataniwha Range, composed of the same rocks, appears in the northern boundary. A range of Palæozoic rocks also appears towards the eastern limits of the northern part, but all the low grounds along the Hokianga valley are formed of Young Secondary and Cretaceo-tertiary deposits extensively overflowed by lava-beds and other volcanic deposits. The high lands to the south, towards the coast-line, are largely formed of a volcanic breccia, which seems to have at one time been continuous over the greater part part of the northern district of Auckland. Towards their base these volcanic breccias are mixed with material derived from sedimentary formations, and the lowest beds of this series are themselves of a sedimentary character, and are at a few places fossiliferous. The following are the localities collected from, and the ages to which the different beds have been referred: Nos. 198 (IV*b*), 729 (VI*e*), 730 VI*f* or VII.), 733 (III.).

HUTT COUNTY.

This is fossiliferous at but a few places. The country is almost wholly formed of Triassic carboniferous rocks which at Karori, Sinclair's Head, and at Terawhiti yield an obscure fossil known as the Mount Torlesse annelid. Plants in rocks of the same age are found along the shore of the upper part of Porirua Harbour, at Ngauranga, and other places, but never in a condition enabling satisfactory determination of even the generic character of the specimens. Tertiary marine-beds are found as a small isolated patch in Makara valley, and recently-consolidated beds are found along the shore of Evans Bay. The Pleistocene fresh-water deposits of Karori basin, and forming the site of the Thorndon division of the City of Wellington, are in many ways of great interest, but as yet have yielded no definite plant-fossils or other forms. The localities of the collections made and the ages of the beds are: No. 95 (III*b*), 200 (I*c*), 317 (I*c*), 430 (XII*a*).

INANGAHUA COUNTY.

Considerable areas of this are occupied by crystalline, granitic, and schistose rocks. The oldest unaltered fossiliferous rocks are of Devonian age. These are finely developed in the vicinity of Reefton, and have been largely collected from in Lankie's Gully, at Rainy Creek, and elsewhere. The lower part of this formation is quartzite and chert, the middle calcareous, and the upper part is a blue slate. The calcareous member is rich in corals, some of the masses of madrepores being of great size. Carboniferous rocks, belonging to the Maitai series of the Survey classification, next succeeded. These latter are the auriferous rocks of the district; and it is a curious fact that, while most of the rich mines lie along and within a short distance of the boundary between these and the Devonian rocks, no reefs are worked, and scarcely any vein-quartz has been discovered in the Devonian rocks, There are no Middle and Old Secondary rocks within the boundaries of the county, and the coal-formation of Cretaceo-tertiary age is the next in succession. Of this, the lower beds are developed chiefly along the eastern side of the Inangahua Plain, and among the hills surrounding Reefton. A vast breccia-formation, evidently formed by glacier action, underlies the coal-formation in the upper part of Boatman's Creek. On the west side of the Inangahua Plain the calcareous higher members of the Cretaceo-tertiary series are present, and fossils have been collected from them at several places.

No Miocene fossiliferous rocks are known within the limits of the county, but between the Inangahua and the Mawheraiti or Little Grey there are vast deposits of gravel, fossiliferous clays, and conglomerates of this age. These yield gold, and at places pay to work. The fossil localities collected from and ages of the beds are: No. 15 (VIII*a* ?), 38 (VI*f*), 48 (VI*e*), 49 (VI*e*), 50 (VI*e*), 129 (XIII.), 130 (XIII.), 508 VI*f*), 727 (VI*f*).

KAIKOURA COUNTY.

The Looker-on Mountains, which are the great physical feature of this county, are formed of Old Secondary and younger Palæozoic rocks that so far have of fossils yielded only a few obscure plant-remains. Along the eastern base of these mountains Young Secondary and Cretaceo-tertiary rocks are deeply involved by faulting. The same rocks appear on the coast-line, between the mouth of the Clarence and Waipapa Boat Harbour, in the Kaikoura Peninsula, and between Amuri Bluff and the mouth of the Conway. In Kaikoura Peninsula and at Amuri Bluff are the principal localities for collecting fossils. At Amuri Bluff the whole sequence is peculiarly rich in a great variety of forms. Reptilian remains abound, and among the molluscan fossils Belemnites, Ammonites, Baculites, Ancyloceras, Inoceramus, Trigonia, and other forms indicate the Secondary age of the lower beds; but associated with these are many forms having a Tertiary aspect. The Grey-marls close the sequence comformably, but contain a fauna having a more purely Tertiary faces, and representing the Lower Eocene. At Amuri Bluff recent marine gravels reach a height of 500ft. above sea-level, and contain many shells not differing from those which may be collected on the neighbouring sea-beach at the present day. The localities collected from and the ages of the beds are: No. 1 (VII.), 2 (VII.), 3 (VII.), 4 (VII.), 6 (VII.), 7 (VII.), 8 (VI*g*), 9 (VI*f*), 10 (VI*e*), 11 (VI*e*), 12 (VI*d*), 13 (VII.), 14 (VI*e, f*), 24 (VII.), 25 (VI.–VII.), 157 (VI*f*), 158 (II*a*), 275 (VI*a, b*), 293 (VI*e, f*), 294 (VI*e*), 555 VI*a*), 568 (VI*f*), 569 (VI*b*), 570 (VII.), 571 (VI.), 572 (VI*g*), 610 (VI*g*), 619 (VI*a*).

KAWHIA COUNTY.

The range of mountains between the Waipa River and the West Coast contains Palæozoic and also Triassic formations, the latter being fossiliferous. On the western slope of the mountains other Middle Secondary rocks succeed till about midway between the range and the coast-line at Albatross Point. At Albatross Point the

Triassic rocks rest on a mass of trachyte or syenite, in character resembling the Sugar Loaves of Taranaki, and from this point the sequence, with an easterly dip, continues till the Belemnite beds at the old mission-station on the south side of the harbour are reached. Cretaceo-tertiary fossiliferous strata underlain by coal-bearing strata are present from the northern to the southern limits of the county, and occur on both sides of the mountain chain dividing the Waipa and Mokau Valleys from the coast-line of the county. Fossils have been collected at the localities of which the Index number and age of the beds are here given: Nos. 276 (VIII*b*), 513 (VI*c*), 515 (VI*e*), 516 (VIII*b*), 517 (VI*b*), 520 (VIII*e*), 521 (VIII*b*), 522 (VIII*b*), 523 (IX.), 524 (X*a*), 525 (X*b*), 526 (VI*b*, *c*), 527 (VI.), 584 (VI.), 646 (VI*f*), 661 (VIII*a*), 663 (VI*b*).

LAKE COUNTY.

Over the greater extent of this the rocks are metamorphic schists and other unfossiliferous crystalline rocks. In the Eyre Mountains a portion of the rocks are unaltered, and belong to the Te Anau series of Upper Devonian age. A broad belt of the same rocks west of Lake Wakatipu extends north-and-south, and reaches the boundaries of the county in each direction. Along the Hollyford Valley these are associated with Maitai rocks, and also rocks of yet younger date that have yielded Lower Secondary fossils. As part of the younger formation, limestones occur at several places, and also Cretaceo-tertiary rocks are found on the sea-coast at Martin's Bay, and at Bob's Cove, on the north shore of Lake Wakatipu; and the same beds extend north-east across Moke and Moonlight Creeks to the Shotover at Stony Creek junction. Along this line these rocks, and also Maitai formation, have been protected from being carried away by denuding agents by their being included in a great fault extending along the line described. Younger deposits of Post-miocene date are found in the valley of the Cardrona River. The same beds in other parts of central Otago contain fossils, but none of this age are known within Lake County. The localities and ages of the beds collected from are: Nos. 63 (VI*e*), 456 (VI*e*), 457 (IV*b*).

MANUKAU COUNTY.

The eastern half of this is mainly formed of Old Secondary or Palæozoic slates and sandstones. To the south and west on these rest the coal-bearing strata of the Lower Waikato, Hunua, and Maraetahi Ranges, on which again rest the greensands of Drury and Papakura, followed by the Orakei Bay beds, the sequence being closed unconformably by the Fort Britomart beds, overspreading which are volcanic sands and clays and decomposed breccia beds of the age of the Manukau breccias that form the coast range north of the entrance to Manukau Harbour, and are the youngest rocks of the district, with the exception of the fossiliferous sands on the east side of Manukau Harbour. Fossils have been collected from the following localities, of which the Index number and the ages are here given: Nos. 101 (VI*d*), 533 (VI.), 534 (VI.), 537 (VI*e*), 538 (VI*e*), 541 (VI. ?).

MANAWATU COUNTY.

Formerly this embraced an extensive area, in which were included a diversity of rocks and several localities at which fossils have been collected. Portions of the area originally thus designated have been taken to form Horowhenua and Oroua Counties, and the Manawatu County now comprises but a comparatively small area of alluvial land along the lower course of the Manawatu River and the coast-line to the north as far as the Rangitikei River, within which no fossils have yet been collected.

MANIOTOTO COUNTY.

Within the boundaries of this to the north and east the older rocks are mostly sandstones and slates belonging to the Maitai and Te Anau series. To the south and west the rocks are all of a schistose character. The central parts comprise the extensive old lake-basin of the Upper Taieri Valley, that of Idaburn, and that of the Upper Manuherikia Valley. On the Kyeburn, and near Naseby, fossils of Cretaceo-tertiary age have been discovered, while Miocene strata also occur at the Kyeburn. In both the cases mentioned the fossiliferous beds are of marine origin. Further to the north-west the oldest of the younger beds filling the old lake-basins are deposits in fresh water, and are of younger date than those already mentioned. Volcanic rocks younger than some parts of the fresh-water lignite-beds appear at the mouth of the Taieri Lake, and in the Upper Manuherikia Valley there are evidences of volcanic action at a date that must be regarded almost as modern. Fossils have been collected at the following places, as indicated below: Nos. 488 (VI*e*), 494 (V*b*), 506 (VI*b*), 512 (III. ?), 753 (VI*e*).

MARLBOROUGH COUNTY.

By far the greater part of this extensive area shows the presence of Old Secondary and Palæozoic rocks. Rocks of Young Secondary and Cretaceo-tertiary date extend along the coast-line from Cape Campbell to the mouth of the Clarence River, and along the base of the Inland Kaikouras from the Upper Flaxbourne to Quail Flat, at the mouth of the Seymour River, and thence within Kaikoura County to the Gore River. Rocks of the same age appear in the middle part of the Awatere Valley, between the Tone and Medway Rivers. In the upper part of the Awatere Valley a great development of volcanic rocks, usually as consolidated ash-beds, intersected by dykes, occupies a horizon inferior to the Amuri limestone, but overlying the lower members of the Young Secondary and Cretaceo-tertiary sequence. At different horizons in these rocks fossils are abundant in both the Clarence and Awatere Valleys. Tertiary rocks of Miocene age, and abounding in fossils, fill the lower part of the Awatere Valley, and stretch east and south-east between the northern end of the Inland Kaikouras and the sea to the Flaxbourne River and Needle Creek, the southern tributary of the same.

Fossils have been collected from the localities of which the Index number and ages are given as follow: Nos. 126 (III*d*), 264 (VI*f*), 265 (III*d*), 314 (VII.), 514 (VI*a*), 518 (VI*g*), 519 (VI*e*), 554 (VI*a*), 559 (III*b*), 561 (VI*a*), 563 (IV*c*), 611 (VI*a*), 612 (VI*a*), 613 (II.), 614 (VI*f*), 615 (VII.), 616 (VI*g*), 617 (VI*a*), 618 (VI*b*), 741 (VI*e, f*).

MONGONUI COUNTY.

This occupies the northern extremity of the North Island from Takau Bay to North Cape. The oldest rocks in the district have been referred to the Lower Carboniferous or Devonian period. They consist of slates, sandstones, and cherts, with massive intrusions of igneous rocks now occurring as diorites. These rocks are often calcareous and serpentinous, but no fossils have yet been found in them.

The next in age is the Cretaceo-tertiary formation, which has a very considerable development within the county, and is at many places fossiliferous, yielding characteristic Secondary fossils. Formation VII. may be considered included with these beds. They have a special development to the west of the upper part of Whangaroa Harbour, north-west of Mongonui, and at Parengarenga, at which latter place coal seams are found in the lower part of the series. The higher beds are present in the Kaeo Valley. Overspreading these and obscuring them over large areas is the volcanic breccia formation of the north district of Auckland, and also at many places are massive floes of basic and acidic volcanic rocks. The lower beds of the volcanic breccia series contain stratified tuffs and sometimes conglomerates formed of rolled fragments of sedimentary rocks. At the base of this series, on the north side of Whangaroa Harbour, are soft grey sandstones, containing numerous plant-remains, and in the same horizon at Mongonui, and at Cooper's Beach, a short distance north of the Town of Mongonui, lignite-beds and oil-shales are developed. At the entrance to Whangaroa Harbour the breccias are of a very coarse description, and form hills of considerable height, which during the process of denudation have assumed the most fantastic forms. The long narrow isthmus connecting the extreme northern part with the southern larger area of the county is formed of drifting sand-dunes, and no fossiliferous rocks appear at the surface.

The localities collected from and the ages of the beds are here indicated: Nos. 76 (VI*f*), 105 (III*d*), 106 (VII.), 107 (VI*a*), 418 (III*d*), 421 (III*d*), 750 (VI*e*), 755 (VI*e*).

OROUA COUNTY.

This shows Old Secondary and Palæozoic rocks east of the Pohangina River, the valley of which is filled with pumice-sands and lignite-beds, which towards the west are overlain by coarse sandstone, gravel, and loamy soils. Fossils have been collected from the pumice-sands and lignite-beds at and near the junction of the Pohangina with the Manawatu, near the lower end of the gorge of the latter river.

The localities and ages of the beds where collected from are here given: Nos. 109 (II*b*), 182 (II*b*), 229 (II*b*).

PATANGATA COUNTY.

This embraces the eastern seaward part of what was formerly Waipawa County. The rocks are for the most part of Cretaceo-tertiary and Tertiary age, but in the north-east corner of the county there is on the coast-line a small area of Lower Secondary rocks.

Fossils occur at many places, but have collected mostly from exposures along the coast-line. The localities, numbers, and ages of the beds collected from are: Nos. 54 (II*a*), 84 (VI. or VII.), 85 (VII.), 86 (V*c*), 87 (V*c*), 113 (IV*b*), 114 (VII.), 115 (V*c*).

PATEA COUNTY

The southern slopes of Mount Egmont lie within the boundaries of this county. Slate rocks are reported as outcropping to the east of the upper part of the Patea River, but these have never been seen by any of the officers of the Geological Survey, and the statement requires verification. The basement-rock of the district is otherwise a Tertiary blue clay, underlying which at places are found patches of shelly limestone of the age of the Waitotara limestone. Over these volcanic detritus, proceeding from Mount Egmont, is widely spread. The later deposits generally obscure the underlying sedimentary deposits, which are usually only exposed along the low cliffs of the coast-line or in the banks of rivers and smaller streams. Fossils have been collected in localities and from beds as indicated below: Nos. 209 (III*d*), 588 (III*d*), 644 (III*b*).

PENINSULA COUNTY.

This is at the surface almost wholly formed of volcanic rocks, yet it would seem that these rest on and obscure an extension in this direction of the Cretaceo-tertiary strata of Green Island and Caversham. The only fossils collected are of recent date from locality numbered 331.

PIAKO COUNTY.

No fossiliferous deposits are known within the limits of this county, and the rocks at the surface are of volcanic origin, or extensive deposits of recent alluvia, and deposits in swamps.

RAGLAN COUNTY.

Towards the east, along the Waipa and Waikato Rivers to the foot of the Taupiri Gorge, the older rocks are probably of Palæozoic age. On the western slopes of the Hakaramata Range Triassic rocks are present; and these, more to the westward, and in the country between the upper part of Whangaroa Harbour and the Lower Waikato, are followed by Liassic and Jurassic rocks, which also appear on the coast-line on the south side of the entrance to the Waikato River. Cretaceo-tertiary rocks are largely developed, the lower or coal-bearing part of the sequence appearing at several places on the Waikato River and within the area of the drainage falling into Whangaroa Harbour. Tertiary rocks of Upper Eocene to Miocene date, if not even younger date, are found along the coast-line north of Whangaroa Harbour. Calcareous sandstones, known as the Raglan and Aotea limestones, form a prominent feature of some parts in the south of the district, and also towards the east of the central northern part. Volcanic products form the basaltic boulder plateau of the north of the district, and on the coast-line south of the entrance to Whangaroa Harbour rises the volcanic mountain Karioi, which, evidently of comparatively recent date, attains an elevation of 2,570ft. above sea-level.

The localities collected from and the age of the beds are: Nos. 39 (VI*d*), 43 (VI.), 51 (VI*d*), 82 (X*b*), 96 (II*b*), 97 (V*b*), 98 (VI*b*), 99 (VI*d*), 112, 123 (VI*g*), 267 VIII*b*), 268 VI*b*), 269 (VI*b*), 272 (VI*a*), 273 (VI*d*), 289 VIII*b*), 301 (VI*a*), 322 (VI*c*), 323 (VI*a*), 409 (VIII.), 528 (VIII*b*), 529 (VI*f*).

RANGITIKEI COUNTY.

The northern part of this area is formed of Palæozoic slates, sandstones being part of the great sequence of sub-metamorphosed sedimentary rocks entering into the structure of the Kaimanawa Mountains. These, however, are generally obscured by overlying Tertiary and volcanic deposits, and can only be traced in a few localities. The Tertiary beds are rich in fossils, but the localities for collection have generally fallen outside the boundaries of the county, locality No. 260 (III.) being the only one that comes under this heading.

RODNEY COUNTY.

Old rocks of Carboniferous or Devonian age appear along the east coast of this part of the northern district of Auckland. Westward these are followed by different members of the Cretaceo-tertiary series, and at places it may be that the lower greensand formation (VII.) also makes its appearance. The higher calcareous members of the Cretaceo-tertiary series are largely developed along the western part of the district, and these at Mahurangi are extensively worked as a hydraulic lime. The term "hydraulic limestone" has therefore been often and generally applied to beds which, in this part of the North Island, are the equivalents of the Amuri limestone in the north-east district of the South Island. At Pahi, Paparoa, Komiti Point, and elsewhere along the east side of the Kaipara Inlet, the beds both above and below the hydraulic or Amuri limestone are rich in fossils, and have been largely collected from. Those at Komiti Point have by some writers been regarded as of Tertiary age, and not at all connected with the Cretaceo-tertiary sequence of rocks.

The Tertiary character of the fossils collected, and the position of the beds as superior to the hydraulic limestone, may be taken as favouring this conclusion. But with respect to the Pahi greensands, the fossils from these are not less Tertiary in aspect, and yet there can be no doubt that the greensands themselves underlie the hydraulic limestones at that place; and to escape the manifest conclusion which must be arrived at if the hydraulic limestone be regarded as part of the Cretaceo-tertiary series, this, it has been asserted, is not the equivalent of the Amuri limestone at all, but a Tertiary deposit having similar characteristics, but of much younger date than the Amuri rock.

Tufaceous volcanic material, sometimes fossiliferous, and bosses of intrusive igneous rocks, occupy not a little of the higher grounds within the limits of the county. The Index numbers of the localities whence fossils have been obtained, and the age of the beds at such places, are: Nos. 246 (IV*b*), 257 (IV*b*), 450 (IV*b*), 451 (VI*a*), 465 (V.), 530 (V.), 531 (V.), 542 (VI.?), 543 (VI*e*), 548 (IV.?), 696 (VI*f*, *g*), 698 (VI*f*), 699 (VI*e*), 700 (VI*d*).

SELWYN COUNTY.

The low ground east of the Malvern Hills, and forming part of the Canterbury Plain, occupies nearly one-third the area of the county, the central and western portion reaching back to the main chain of mountains, and the water-divide of the island is, with the exception of the broad open parts of the Rakaia Valley, of a highly mountainous character. The oldest rocks belonging to the Carboniferous period, or the Maitai series of the Survey classification, are found along two lines, the eastern of which is well exposed in Mount Hutt, and, continued to the north-east, is again well seen in Mount Torlesse. The western belt of Carboniferous rock shows in Mount Arrowsmith, and is continued across the Rakaia watershed to the Waimakariri, between the Cass and Bealey junctions. The same rocks undoubtedly form part of the main range itself, but the outcrops are mainly on the western slopes, within Westland County. A few obscure fossils are found in these beds, the better known of which is the Mount Torlesse annelid, which is of almost universal occurrence wherever these rocks are found.

Younger rocks of Permian and Secondary age occur as two synclinal arrangements trending in the same general north-east direction, and on the eastern borders of the mountainous tract a third area of Triassic and Middle Secondary rocks is met with in the Malvern Hills. The western area of these younger rocks further to the south, within Ashburton County, is richly fossiliferous in Mount Potts, and there can be little doubt but that the beds are also fossiliferous within the boundaries of this county. Fossils resembling Inoceramus have been collected in the Waimakariri Valley, above the junction of the Cass River, but at the time these were thought to be the same as those found in the Maitai slates of Wooded Peak, Dun Mountain, Nelson; it is probable, however, that they belong to the younger sequence. The eastern syncline is a continuation to the north-east of the Clent Hills plant-beds, which pass through the ranges immediately west of the Trelissick Basin, and reach across the Waimakariri Valley into Ashley County, in which the presence of Liassic and Triassic rocks has already been noted. The eastern exposure of Middle and Old Secondary rocks lies mainly within the Malvern Hills, where they yield a Jurassic flora not different from that which has been collected from the Secondary rocks in the Clent Hills. The next younger rocks are the acidic intrusive or volcanic rocks of the western part of the Malvern Hills, on these, at many places, lie the coal-bearing sequence. The coal-bearing rocks are underlain by a breccia derived mainly from the igneous rocks just mentioned. The beds of the same sequence immediately following the coal in the Malvern Hills and in the Trelissick Basin are richly fossiliferous. These beds represent the middle and lower parts of the Amuri Bluff section, but contain scarcely any distinctively Cretaceous forms, and the whole fauna has such an aspect as has led some observers to the conclusion that these beds belong to the

Tertiary period; of late, however, complete proof of their Secondary age has been obtained. In the Trelissick Basin the higher Cretaceo-tertiary beds are also present, besides a richly fossiliferous development of Tertiary strata, the whole being enclosed among mountains formed of Old Secondary and Palæozoic strata. The preservation of these younger rocks of the Trelissick Basin is in the main due to their being so deeply involved among the older rocks as to have thus far escaped complete destruction by the ordinary processes of denudation. Like remnants, thus preserved, of Cretaceo-tertiary and Tertiary strata, are found in other parts of the county. Collections of fossils have been made from localities of which the Index numbers and age are here given: Nos. 23 (VI*e*,*f*), 67 (VI*f*), 226 (IV*b*), 234 (IV*b*), 235 (III.), 236 (IV*b*), 237 (V*a*), 238 (V*a*), 239 (V*c*), 240 (VI*b*), 241 (VI*e*), 242 (VI*b*), 243 (V*c*), 244 (IV*b*), 298 (VI*f*), 311 (V*a*), 422 (VIII.), 423 (VI*f*), 424 (VI*f*), 425 (VI*f*), 429 (XII*a*), 449 (VI*e*), 450A (V*a*), 451A (IV.), 452A (IV.), 453A (V.), 454A (V.), 456A (IV*b*), 469 (VI*f*), 549 (V. and VI.), 589 (VI*e*), 590 (VI*e*), 591 (VI*e*), 754.

SOUNDS COUNTY.

The western parts of this are formed wholly of crystalline metamorphic, schistose, and subschistose rocks; the eastern parts of various unaltered Palæozoic and Old Secondary formations, ranging from Upper Devonian to Permian in age. Cretaceo-tertiary rocks occur near the Town of Picton, and are in that vicinity deeply involved by faulting. Coal is found at Shakespeare Bay. The coal-beds are overlain by limestones followed by greensands, which are again followed by a calcareous argillaceous rock representing the Amuri limestone: this on losing its lime decomposes to a light brown colour; and in both this and the unchanged rock exposed in the deep railway-cutting of the Elevation, two miles from Picton, fossils are found; these are not usually in a good state of preservation, and this, together with the indurated condition of the calcareous argillaceous rock, has led to the assumption that the beds are of much greater age than in reality they are. Fossils collected from this locality bear the Index number 57, and are in age referred to VI*a*, and at Shakespeare Bay to VI*e* or *f*.

SOUTHLAND COUNTY.

The north-east part of this is formed of crystalline schists and semi-schistose rocks. The north-west part shows the presence of unaltered rocks belonging to the Te Anau and Matai series. Over the whole of the central and southern parts, fossiliferous rocks, Secondary and Cretaceo-tertiary, or widespread alluvial deposits, are found, except in the Green Hills and at the Bluff, where rocks belonging to the Te Anau series are again found. The Secondary rocks, including also the Permian, are developed between the Oreti and the eastern slopes of the Takatumu Mountains, and, as a vast development of evenly-bedded strata, occupy the whole of the Hokonui Hills and that part of Southland County lying to the east of the Mataura River. These have been carefully studied, and the limits of each formation determined by means of the changing character of the rocks and fossils which they contain. In determining the age of the Middle and Old Secondary bed the horizon of *Monotis salinaria* and of *Mytilus problematicus* has been of the greatest service, as also has been the horizon of *Belemnites canaliculatus*. Below the first lie the Permian beds of North Peak and the whole of the north-east slope of the Hokonui Hills. Over the Belemnite beds come the estuarine Mataura series, rich in fossil plants, which must be referred to the period of the Upper Oolite.

Cretaceo-tertiary beds, consisting of grits and fireclays overlain by marly strata and calcareous sandstones, form the Forest Hill Range and the low grounds between that and the western slopes of the Hokonui Hills, and also appear as an isolated outcrop of calcareous rock in the middle of the Waimea Plain. The grits, &c., with coal-seams, skirt the flanks of the Hokonui Hills on the west side and their southern end as far as opposite the Township of Gore. At places these grits have proved auriferous, but as yet no extensive workings of them have taken place.

A younger series of lignite beds, shaly clays, and quartz-grits is extensively developed in the district. The lignites of this series, which probably are of Miocene age, are worked at Mataura Falls, at Waimea Station, and at Waikaka (Switzers) and other places, affording a valuable local supply of fossil fuel, which is all the more valuable on account of the treeless character of much of the country over which these beds extend. Fossils have been collected from the following localities, the Index numbers of which and the ages of the beds are as given below: Nos. 132 (IX*a*), 137 (X*a*, *b*), 138 (X*b*), 144 (IX*a*), 145 (IX*a*), 245 (IV*b*), 247 (V*a* or VI.), 256 (VI*a*), 258 (V. or VI.) 332 (VIII*b*), 333 (VIII*b*), 334 (VIII*b*), 335 (VIII*b*), 336 (VIII*b*), 337 (VIII*b*), 338 (VIII*b*), 339 (VIII*b*), 340 (VIII*b*), 341 (VIII*b*), 342 (VIII*c*), 343 (IX*a*), 344 (IX*a*), 345 (IX*a*), 346 (IX*a*), 347 (IX*a*), 348 (IX*a*), 349 (IX*a*), 350 (IX*a*), 351 (IX*a*), 352 (IX*a*), 353 (IX*a*), 354 (IX*a*), 355 (IX*a*), 356 (IX*a*), 357 (IX*a*), 358 (IX*a*), 359 (X*a*), 360 (X*a*), 361 (X*a*), 362 (X*a*), 363 (X*a*), 364 (X*a*), 365 (X*a*), 366 (X*a*), 367 (X*a*), 368 (X*a*), 369 (X*a*), 370 (X*a*), 371 (X*a*), 372 (X*a*), 373 (X*b*), 374 (X*b*), 375 (X*b*), 376 (X*b*), 377 (XI*a*), 378 (XI*a*), 379 (XI*a*), 380 (XI*c*), 381 (XI*c*), 403 (VIII*a*), 406 (VIII*a*), 407 (VIII.), 426 (VIII*a*), 427 (VI*f*), 452 (IV.), 459 (IX*a*), 461 (IV*a*), 470 (VIII*c*), 471 (VIII*c*), 455 (VIII*a*), 666 (VIII*a*), 667 (VIII*a*), 668 (VIII*a*), 669 (VIII*a*), 670 (VIII*a*), 671 (VIII*a*), 672 (VIII*a*), 673 (VIII*b*), 677 (VIII*a*), 752 ( ).

TAIERI COUNTY.

The whole of the northern and central part of this, west of the Taieri River, is formed of foliated metamorphic schists. East of the Taieri Plain the fundamental rock is also schist in the northern part, but Cretaceo-tertiary rocks, as grits and shales, with seams of inferior brown coal, are present at many places. These are frequently capped by remnants of extensive floes of basic volcanic rock of still later date. The quartz-grits are often auriferous. The schist rocks abound in reefs of quartz-carrying gold, antimony, and small quantities of copper. In the southern part of the district the schistose rocks never actually reach the seaboard to the north of Dunedin, and do so to the south-west of Dunedin only for a short distance at New Brighton. On the north-east side of the Lower Taieri Gorge semi-metamorphic rocks are present and form the coastward range of hills for a few miles to the north-east of Taieri mouth. Cretaceo-tertiary rocks extend along the coast-line from the northern boundary to Blueskin, and thence follow the Silverstream Valley to where that opens out on the Taieri Plain. Grits and quartz-gravels are largely developed along this line, but to the eastward the higher ground of Mount Cargill and Flagstaff Hill are formed of volcanic rocks. From Blueskin, along the valley of the Waitata, the higher calcareous rocks of the series are continued from the coast-line to the north-east to the saddle leading into the valley of the Water of Leith. Beneath these rocks are dark shaly beds, in association with which are thick beds of oil-shale of considerable value. South-west of Dunedin lies the Green Island Coalfield, which again shows the quartz-grits and sands resting on the schistose rocks of the Chain Hills and the north-western base of Saddle Hill. The grits and coal-measures are followed by greensands, and at Burnside, and in the hills to the seaward side of the railway-line by the Caversham sandstone, a calcareous sandstone, corresponding to VI*b*. of the Survey classification. Through this the Caversham Tunnel has been driven, and this, as the highest sedimentary rock of the Cretaceo-tertiary series, disappears under volcanic rocks in the near vicinity of Dunedin. Between Saddle Hill and the Lower Taieri River a trough between Allen's Range and the coast range is filled with quartz-grits, shales, and soft sandstones, in which, associated with these beds, occur thin seams of coal, which there is every reason to believe belong to the Green Island series and form part of the Cretaceo-tertiary sequence as developed along the seaboard of eastern and south-eastern Otago. But from Otakia to the Taieri River the highest rocks occupying this area are of a remarkable character, consisting as they do of a great thickness of exceeding coarse brecciated material, composed almost entirely of *débris* from the schistose area, occupying the country to the north and north-west beyond the low grounds of the intervening Taieri Plain. These are known as the Henley breccias. The material of which they are composed in size and character closely resembles a morainic deposit, the result of vigorous ice-action over the area, whence this deposit has been derived. Vast blocks of schist, 6ft., 8ft., or 10ft. in diameter, and in cases even 20ft. in diameter, are included in the middle and upper parts of this deposit. The lower beds partake more of the nature of a conglomerate, and downwards the beds pass into sands and sandy clays, which, in the neighbouring County of Bruce, within the upper Township of Waihola, yield marine fossils, indicating a Miocene age for these lower beds. North-east of the Taieri these lower beds rest with apparent conformity on quartzose sands, shales, and grits, which, it has been stated, are a probable extension south-west of the rocks of the Green Island and Saddle Hill Coalfield. Dykes of basic volcanic rock break through the lower beds at Otakia and at Waihola. This is a very remarkable formation, and requires further close study to determine its exact age and its relation to the other younger formations within this district. Fossils have been collected from the localities indicated below, and the ages of the beds present are indicated as above: Nos. 22 (VI*e*), 53 (VI*b*), 309 (VI*b*), 609 (VI*e*), 628 (VI*e*).

TARANAKI COUNTY.

This extensive area shows the presence of the older and Middle Secondary rocks only in its northern part within the valley of the Mokau River in small patches, as, for instance, at the Wairere Falls. At different places within the same river-system are exposed the lower beds of the Cretaceo-tertiary, containing valuable seams of coal. The middle and higher beds of the same series are also well exposed, and consist of greenish-sandy strata, followed by calcareous rocks, either as calcareous sands or foraminiferous limestones. From both of these divisions fossil-collections have been made, and from the lower greensand beds a considerable number of species have been obtained. Between the lower part of the Mokau Valley and the mouth of the Waitara River the sea-cliffs expose grey marly or sandy clay-strata, which contains a fauna which has been referred to the Tertiary period. The middle and southern parts of Taranaki County towards the coast-line show, with rare exceptions, only volcanic rocks at the surfaces. On the south-western extremity rises the great and beautiful volcanic cone of Taranaki, or Mount Egmont, the vent or vents of which, besides building up the majestic mountain, have spread volcanic detritus far and wide over the surrounding country. The eastern parts, towards the Wanganui River, expose at the surface the coal-formation, and coal is known to outcrop at several places.

Fossils have been collected from several places, which, with the ages of the beds, are indicated thus: Nos. 52 (VI*a*), 453 (III*b*), 582 (II.), 583 (IV.), 630 (VI.), 654 (VI*f*), 655 (VI*b*), 656 (IV*a*), 657 (VI*b*), 658 (VI*b*), 664 (VI*b*).

TAURANGA COUNTY.

No fossiliferous sedimentary rocks are known within the boundaries of this county. The whole surface is covered with material of volcanic origin, and of comparatively recent date, except towards the north-east corner of the area, within which the rocks may be of the character and age of the auriferous tuffs of Cape Colville Peninsula.

TUAPEKA COUNTY.

This is almost wholly composed of crystalline metamorphic rocks, comprised under the term foliated schists. With the exception of river alluvial and the breccia cements of the Blue Spur, and some areas of quartz-grit and clays with lignite of limited extent, there are no other rocks in the district.

VINCENT COUNTY.

The lower foliated schists of the great anticlinal, running south-east through central Otago, occupy a very large extent of this county. The north-west corner is occupied by schists occupying a higher position, and these are less foliated with quartz than the central and deeper-seated rocks. On the east side of the extreme northern part the rocks are unaltered slates and sandstones of Palæozoic age.

In the central and southern parts young rock, the result of deposits in the extensive old lake-basins, so called, of interior Otago, are developed at many places, principally in the Manuherikia Valley, and from Cromwell along the Bannockburn and Nevis Rivers, and on the banks of the Clutha, at the junction of the Cardrona. Associated with these rocks are heavy beds of lignite or brown coal, and the sands and clays at many places contain, besides fossil leaves, the remains of birds, fish, and fresh-water mollusca. Heavy sandstone gravels overlie these beds, or rest on the old schistose rock, and these, largely developed in the Lindis Valley apart from the extended moraines, surround the lower parts of Lakes Wanaka and Hawea, and are the youngest rocks of the district that need be mentioned in this place. Fossils have been collected at places and from beds as indicated below: Nos. 419 (IV. ?), 510 (IV. ?), 511 (IV. ?).

WAIKATO COUNTY.

In the central and northern parts of this old rocks, probably of Palæozoic age, form ranges of hills trending in an east-and-west direction. The southern upper part of the county is composed of wide-spread volcanic deposits of Tertiary age, and extensive areas of swamp or river alluvia. In the lower Waikato basin a large area also is swampy, showing nothing but peaty deposits or volcanic detritus at the surface. Round the margins of these extensive swampy lands, in the lower basin of the Waikato, Cretaceo-tertiary rocks appear; in the lower beds of this formation thick deposits of brown coal are found, and the higher overlying clays and marls are frequently fossiliferous. Fossils have been collected from places the Index number of which and age of the beds are: No. 100 (VI*d*).

WAIKOUAITI COUNTY.

West of Shag Valley schist forms the fundamental rock of the district, while on the north-east side of this valley the rocks are unaltered slates, sandstones, and breccias belonging to the Kakanui series = the Maitai and Te Anau series.

In the upper part of Shag Valley, along Greenburn Valley, fossiliferous Cretaceo-tertiary rocks are found, and in the middle and lower parts of the valley the same rocks are found—as limestones at Waihemo, and as grit-sands and sandy clays, with concretions extending continuously along the east side of the valley—from Kitchener's Station to Puke Iwitai.

South of the Shag River the whole coast-line shows the presence of Cretaceo-tertiary and Tertiary rocks. These extend inland to Taieri Peak, near the source of Pleasant River, and through Mount Watkins to and beyond the Stoneburn, where in Hummock Side coal strata with seams of coal are developed. Within the northern part of the district, between the Taieri and the Upper Shag Valley, quartz-grits of Cretaceo-tertiary age are overlain by basaltic rocks, and from Palmerston west to the Stoneburn basic volcanic rocks overlie unconformably different members of the Cretaceo-tertiary series. The fossil localities collected from and the age of the beds at those places are here indicated: Nos. 507 (VI*e*), 594 (VI*e*), 598 (VI*e*), 599 (VI*d*), 601 (V*b*), 602 (V*b*), 603 (VI*c*), 604 (VI*e*), 605 (VI*b*), 607 (VI*a*), 608 (VI*a*), 620 (VI*b*), 621 (IV*c*), 632 (IV*c*).

WAIMATE COUNTY.

The higher elevations of the northern and western parts—the Hunter Hills, and the range between Waimate and the Waihoa River where it leaves the hills and enters upon the seaward plain, and generally the hills on the east side of the Waitaki Valley from opposite the junction of the Maraewhenua to the north-west corner of the county, are formed of old Secondary and Palæozoic rocks. The oldest rocks present belong to the Te Anau series, and are well and characteristically seen in the gorge of the west branch of the Waihoa River. Triassic rocks are found in Station-peak Range, and in the mountains to the north-west of the Hakateramea Valley. The Cretaceo-tertiary rocks lie principally within the Waihoa Valley and along the eastern flanks of the Hunter Hills. These are almost everywhere followed by Tertiary rocks belonging to the Miocene period or the Pareora series of the Geological Survey Classification. The lower grounds and slopes of the hills on each side of the Hakateramea Valley also show the presence of younger rocks, mainly of Tertiary date. At almost all places these younger formations abound with fossils, and some important collections have been made from this area. Differences of opinion still exist as to the age of the beds in the middle Waihoa basin, a Tertiary and a Cretaceo-tertiary age having been imputed to them by different writers. The fossil localities and the ages of the beds collected from are as below indicated: Nos. 165 (IV*b*), 166 (IV*b*), 167 (VI*f*), 475 (IV*b*), 477 (V*c*,) 479 (VI*e*), 480 (VI*e*), 482 (VI*b*), 485 (VI*a*), 642 (VI*f*).

WAIMEA COUNTY.

The features and geology of this are alike varied. The oldest rocks are found in the western part of the district, along the watershed of the Motueka River and its tributaries, the Baton and the Wangapeka. The granite and schist of this part of the district may be considered the oldest rocks. Next follow the Lower and Upper Silurian rocks of the Baton and Wangapeka Rivers, and the Mount Arthur Range and its continuations to the north-east. These rocks are richly fossiliferous, and have been largely collected from. The next succeeding formation—the Te Anau series of Devonian age—is developed in the Dun Mountain Range and in Ben Nevis, on the opposite eastern side of the county. This includes, or is followed by, the rocks of the Dun Mountain mineral belt, on which rest the Maitai limestones of Lower Carboniferous age. These are fossiliferous, and yield fossils characteristic of the period to which the limestone has been referred. The Maitai slates and sandstones next succeed, and are developed along the whole length of the Dun Mountain and Ben Nevis Ranges, from the French Pass to Tophouse Saddle, and are also present in the Hope River Valley and in the north-eastern lower slopes of Mount Owen. These are fossiliferous at a few places in the Maitai Valley, on Wooded Peak, and in Aniseed Valley. Between the Maitai slates and sandstones and the next succeeding rocks of Permian age there is placed the unconformity which divides the Palæozoic series from the Permian and Old Secondary sequence, which is continued upwards to the close of the Jurassic period. The Permian rocks of the Nelson District have been determined by means of fossils over but a limited area in Eighty-eight Valley, south-east of Wakefield. They are at this place richly fossiliferous, and yield a great number of species characteristic of the beds in the Hokonui Hills, and in the Kahiku Range, Southland and Clutha Counties. On these Permian beds of Eighty-eight Valley rest Triassic and Rhætic rocks, forming a lower range of hills between the Dun Mountain Range and the low alluvial grounds of the Waimea Plain. These beds are richly fossiliferous at the Wairoa Gorge, and in the range of hills on the south-west side of the gorge towards the source of Spring Grove Creek. Here, besides the characteristic *Monotis salinaria* and *Mytilus problematicus*, they yield a rich fauna of Cephalopoda and other molluscous forms, besides a limited though characteristic flora. At various times these beds have been largely collected from. The Cretaceo-tertiary formation is the next in age present within the district. This is seen to best advantage between the Baton River and the gorge of the Wangapeka River, below the junction of Rolling River. Gritty shales and coal-measures form the lowest beds, which are faulted and partly inverted along the eastern base of the Mount Arthur Range between the points mentioned. Towards the source of the Wangapeka is another interesting development of these lower beds, whence have been obtained a great number of plant-remains characteristic of, or taken typically to characterize, this horizon of the Cretaceo-tertiary series. Greensands and marly strata overlie the coal-bearing lower part of the sequence. These are richly fossiliferous at the Baton River, at which place the series is closed by chalky, marly limestones, resembling the hydraulic limestone of the north of Auckland. On the east side of the district the coal-beds show as sandstones and shales along the road through the Big Bush, between the Upper Motueka and Tophouse; also at Jenkins Hill, near Nelson. The higher beds of the series are developed near Nelson, and are well shown in the deep railway-cuttings close to Bishopdale Station. Tertiary beds show along the north-west side of the Port Hills, and at the lower end of the Wairoa Gorge,—possibly also on the Sherry River, where are fossiliferous beds the exact age of which has yet to be determined. Almost the whole of the central region, from the shores of Blind Bay to the Buller watershed, is formed by the Moutere gravels, a Pliocene accumulation of well-rolled river-shingle, which generally attains a very great thickness, and reaches from the lowest grounds to a height of 3,000ft. above sea-level. Fossils have been collected at many places, of which the Index number and the ages of the beds are here given: Nos. 42 (VI*f*), 62 (VI*d*), 128 (XIV*a*), 139 (X*b*), 140 (X*b*), 141 (X*b*), 142 (X*b*), 143 (XII*a*), 195 (IX*a*), 196 (IX*a*), 197 (IX*a*), 215 (VI*e*?) 303 (III.?), 318 (IV*b*), 319 (IV*b*), 324 (VI*e*), 382 (X*b*), 383 (X*b*), 384 (X*b*), 385 (X*a*), 386 (X*b*), 387 (X*b*), 388 (XII*a*), 389 (XII*a*), 390 (X*b*), 391 (X*b*), 392 (X*b*), 393 (X*b*), 394 (X*b*), 395 (X*b*), 396 (XII*a*), 397 (XII*a*), 398 (XII*a*), 399 (XII*a*), 400 (XII*a*), 413 (VI*f*), 432 (X*b*), 433 (X*b*), 434 (X*b*), 435 (X*b*), 436 (XI*a*), 437 (X*a*), 438 (X*b*), 439 (X*b*), 440 (X*b*), 441 (XII*a*), 442 (X*b*), 443 (X*b*), 444 (XIV*a*), 445 (XIV*a*), 446 (XIV*a*), 447 (XIV*b*), 448 (XIV*a*), 462 (VI*e*), 463 (VI*d*), 468 (IV*b*), 473 (XII*a*), 726 (VI*f*).

WAIPA COUNTY.

Within this is almost wholly comprised the alluvial area between the Lower Waipa and Waikato Rivers, and consists of alluvial pumiceous deposits or extensive areas of swampy land. No fossiliferous rocks are known, though such may exist in the southern part along the valley of the upper part of the Puniu River.

WAIPAWA COUNTY.

The fossiliferous localities of the southern part are contained within the upper basin of the Manawatu River. The older rocks of the Ruahine Range are probably fossiliferous at places, but fossils have yet to be discovered. The deposits filling the low grounds on the west side of the basin are all of Young Tertiary date. The northern part of the county, embracing part of the watershed of the Tukituki and Waipawa Rivers, contains round the borders of the Ruataniwha Plain many outcrops of richly fossiliferous Tertiary strata, and also in the north-east part the Cretaceo-tertiary formation is largely developed. From the higher beds of this latter, in the Waipawa Gorge and near Kaikoura, Ammonites and a few other Secondary fossils are found. The Index numbers of the localities whence fossils have been collected and the ages of the different beds are here given: Nos. 181 (III*b*), 183 (II*b*), 184 (II.), 185 (II*c*), 186 (VI*d*), 187 (III*d*), 692 (VI*e*), 693 (III*d*), 694 (III*c*), 708 (III*a*), 737 (III*a*).

WAIRARAPA NORTH COUNTY.

Within this lie the eastern slopes of the northern part of the Tararua Range, composed of Old Secondary and Palæozoic rocks. From the water-parting between the Ruamahanga and the southern tributaries of the Manawatu River, a spur of these older rocks goes east in the direction of Alfredton and the source of the Tiraumea River; from this again a ridge of these older rocks goes south between the watershed of the Wharehama and Taueru Rivers. These rocks are fossiliferous four miles to the south of Eketahuna, where limestones in connection with dark slates, sandstones, and volcanic tuffs are found. Young Secondary and Cretaceo-tertiary rocks are present along the east coast, and are fossiliferous sparingly at most places, but yield Inoceramus and a few other forms abundantly in the valley of the Akiteo River, and thence along the coast to the northern boundary. A white subcrystalline limestone, and a grey foraminiferous limestone belonging to this series are found in the ranges to the north-west of Castlepoint. Tertiary rocks have a very considerable development within the county, and have been largely collected at Castlepoint. At the Taipos, and in the Maungapukea Valley, in the Taueru Valley, and along the watershed of the Kopuerangi River.

The fossil localities, as indicated by the Index number and the ages of the beds, are: Nos. 5, (VI.), 37 (III*b*), 81 (III*b*), 93 (IV*b*), 94 (III*b*), 117 (IV*a*), 118 (VI. or VII.), 119 (I*e*), 121 (IV*b*), 201 (IV*b*), 250 (IV*b*), 749.

WAIRARAPA SOUTH COUNTY.

The eastern slopes of the Rimutaka Range and the eastern slopes of the Tararua Mountains, which lie within the western borders of this county, are formed of Old Secondary and Palæozoic strata, consisting of grey sandstones and slaty shales, often of a drossy serpentinous character. Grey and red cherts, and jasperoid siliceous slates, also form permanent bands in these rocks. Green diabasic tuffs are also at places greatly developed, and these latter are often of a highly-calcareous character.

On the eastern side of the Lower Wairarapa Valley the Haurangi Mountains, extending to the East Coast between Cape Palliser and the Awhaenui River, are formed of the same rocks, and they also form the coast-range between Tawhiti and the mouth of the Pahua River, and are characteristically developed in the southern part of the Maungaraki Mountains, on the north-east side of the gorge of the Pahau River. Cretaceo-tertiary rocks occupy the greater portion of the eastern sea-board and the lower portion of the Wharehama Valley; these yield Inoceramus at the mouth of the Pahua, and *Trigonia sulcata* in the upper part of the Motuwairiki or Korokoko River. On the east side of the Upper Pahau Valley, Cretaceo-tertiary rocks are again found resting on the western slopes of the rugged range of the "Brocken," on Branspeth Run, and the Cretaceo-tertiary rocks continue along this line till interrupted by the east and west extension of the Tertiary beds, forming Morrison's Taipos. From the east side of the Pahau Valley to the Ruamahanga River, the whole country is formed of Tertiary rocks, representing Formations II. and III. The Wairarapa shelly limestones constitute the great feature of this part of the district, but in the Taueru sands and the underlying clays with concretions a great thickness of strata is represented.

Within the Ruamahanga watershed, the Wanganui formation is represented, and is richly fossiliferous along the Hautotara River and in the sea-cliffs at the mouth of the Ruamahanga and outlet of the Lower Wairarapa Lake.

Fossils have been collected from localities, which, with the ages of the beds, are indicated thus: Nos. 108 (III*b*), 545 (II*b*), 580 (III*b*), 581 (III*b*), 749 (II.).

WAIROA COUNTY.

The oldest rocks within the limits of this county are confined to the south-west part, and form a block of mountainous country on the north-west side of the Mohaka River, between the junction of the Waipunga and the gorge and sharp bend in the course of the Mohaka, at the north-east end of the Maungaharura Range. These are probably of Old Secondary date. Below the junction of the Waipunga these rocks show on the right bank of the Mohaka. Young Secondary rocks are met with on the shore-line of Hawke's Bay, between the mouth of the Nuhaka and Mahia Peninsula, and also on the coast-line to the north of the peninsula. These rocks, though not fossiliferous, are unlike those already mentioned, and closely resemble rocks of this age at many parts of the coast-line of the Cook County. They extend inland but a few miles, and are limited to the east of a line drawn from the Lower Mohaka north to the coast at Whareongaonga. Marly and sandy clays of a light grey colour are seen in the western part of Mahia Peninsula, which have been referred to the Cretaceo-tertiary period, but, as there is here the probability of an unconformity between these and the rocks last noted, there is some doubt as to the correct reference of these beds. With these exceptions the whole of the area of the country shows the presence of Tertiary strata only. A vast section of strata along the Waikaretaheka branch of the Wairoa River. In this on the eastern shore of the Waikare-moana Lake, calcareous and marly sandstones rise to a great height above the waters of the lake. These are composed of strata that may be regarded as of Lower Tertiary age. The lake itself occupies a depression on the downthrow side of a great fault, of which the eastern shores of the lake give everywhere ample evidence, and evidence that the fracture is of quite recent date. On the western and north-western sides the waters of the lake fill a series of valleys separated by high ridges of hills, and in this respect is very unlike the south-eastern shore, which is a continuous line of precipices 500ft. to 1,000ft. in height, with very deep water at their base. The rocks on the north-west side of the lake are of younger date than those forming Panakeri, and the cliffs on each side of the outlet of the lake and in the choked ravine of the upper part of Waikaretaheka River; but the strike and dip of the strata on both sides of the lake are the same. Pareora (Lower Miocene) fossils were collected on the northern shore of the lake, where the Maori track, leading to the Upper Wakatane and the centre of the Uriwera country, starts from the furthest reach of the long northern arm of the lake. These Tertiary rocks form the main water-divide between the waters flowing to Hawke's Bay on the one hand and to the Bay of Plenty on the other.

Fossils have been collected at the places of which the Index numbers and the ages of the beds are here given: Nos. 285 (II*c*), 687 (II*c*), 689 (I*a*), 704 (VI*a* ?), 706 (II*b*), 706 (IV ?), 722 (III).

WAITAKI COUNTY.

The oldest rock of this area constitute Mount Domett and the Kurow Range and a small area on the north-west side of the Papakia Plain, between Black Point, in the Waitaki Valley, and the south-west base of Big Hill. These are of a schistose or sub-schistose character. Such rocks also appear in the far north of the county in the deep mountain glens and ravines of the Southern Alps drained by the western tributaries of the Hopkins River, that, after being joined by the Dobson, falls into Lake Ohau. The Te Anau series is represented along the eastern slopes of the Kakanui Mountains, and also in the mountains to the westward of Lake Ohau, and the Maitai series of Carboniferous age is also present in this northern part of the county. Triassic rocks are probably present in the Kakanui Mountains towards and around the source of Trotter's Creek.

Gravels containing Triassic fossils are found in the Waitaki Valley, two miles below Kurow Railway-station, showing that rocks of that age are present somewhere within the watershed of that river. The probability is that the rocks yielding these fossils are to be found on the Canterbury side of the valley.

Cretaceo-tertiary rocks are present along the whole eastern flanks of the Kakanui Mountains, and of the Kurow Mountains as far up the Waitaki Valley as Wharekuri, and on west the side of Mount Domett and the Kurow Mountains, where auriferous sands, belonging to the lower part of this series, are found and worked at a height of 4,000ft. above the sea. The lower beds of this series are also worked for gold at the Maerewhenua diggings. At this latter place the auriferous quartz gravels gradually pass upwards into marine greensands, which are fossiliferous, and at the same time auriferous.

The gold obtained for many years on the Hampden or Moeraki Beach has also, it is very evident, been derived from the Trotter's Creek breccia conglomerates, and the lower quartz-grits of the Cretaceo-tertiary sequence in this part of the district. Coal-beds are generally developed in seams of varying thickness along the eastern flanks of the Kakanui Mountains, at Shag Point, and on the south-eastern slopes of Big Hill, west of the Papakaia Plain. Marine fossiliferous strata, as light-brown sandstones, overlie the coal-measures, and these are followed by dark, earthy, sandy beds, containing concretions which have yielded saurian remains. Dark-coloured glauconitic greensands (Trotter's Creek greensands) overlie, and dark slaty shales or marly strata, which in turn are succeeded by the Moeraki boulder-beds, and these in turn by the Onekakara Beach beds, which are richly fossiliferous.

In the district between Hampden and Oamaru, and as far as Windsor on the Oamaru-Livingstone Railway, the Waireka tuffs next succeed, followed by clay or chalk-marls containing numerous fossils. These latter are well displayed near the Township of Kakanui, below the railway-crossing of the Kakanui River at that place. In the same horizon at Cave Valley, four miles north-west of Oamaru, there is a thick deposit of diatomaceous earth overlying the Waireka tuffs, and underlying the Ototara limestone (Oamaru building-stone). The same horizon has developed in the Moeraki Peninsula chalky clays, which are rich in marine fossils, especially turbinate corals. The Ototara limestone, in the Waitaki Valley, is represented by the Maerewhenua limestone, and possibly by the Otakaika limestone, though this latter more probably belongs to the Tertiary period. Calcareous sandy beds with concretions overlie the Maerewhenua limestone, and these, representing the Grey-marls, are the closing beds of the Cretaceo-tertiary sequence.

Tertiary beds of Upper Eocene date are found in the neighbourhood of the Town of Oamaru and in the Waitaki Valley, between the Otokaik River and Wharekuri. White Tertiary strata of Miocene age is found along Awamoa Creek, and along the seaward range of hills north of Oamaru. These Tertiary beds abound in fossils, and the Eocene beds in the Waitaki Valley yield abundantly remains of *Kekenodon onamata* (Hector). Fossils have been collected from localities, the Index numbers of which, and the ages of the beds, are:

Nos. 168 (VI*e*), 169 (VI*b*), 170 (IV*b*), 171 (VI*e*), 172 (V*b*), 173 (V*b*), 174 (V*b*), 175 (IV*b*), 176 (VI*c*, *f*), 177 (VI*f*), 178 (VI*a*), 179 (VI*b*), 213 (IV*b*), 214 (VI*e*), 224 (VI*e*), 248 (V*c*), 251 (V*c*), 252 (V*c*), 253 (V*c*), 254 (IV*b*), 255 (V*b*), 288 (VI*d*), 299 (I*e*), 308 (V*b*), 310 (V*c*), 312 (V*b*), 320 (VI*f*), 327 (V*b*), 414 (VI*f*), 476 (V*d*), 478 (V*c*), 481 (V*c*), 483 (V*b*), 484 (VI*b*), 486 (VI*c*), 487 (VI*e*), 489 (VI*b*), 490 (VI*c*), 491 (V*b*), 492 (V*b*), 495 (VI*b*), 496 (VI*b*), 498 VI*b*, *c*), 499 (VI*e*), 500 (VI*c*), 501 (VI*e*), 550 (III.), 552 (X.), 592 (VI*e*), 593 (VI*e*), 595 (VI*e*), 596 (VI*e*), 597 (VI*e*), 600 (VI*b*), 606 (VI*b*, *c*), 622 (VI*e*), 623 (VI*c*?), 624 (V*b*), 625 (IV*c*), 626 (V*b*?), 627 (VI *b* or *c*), 631 (VI*f*), 674 (V*a*), 675 (VI*c*), 676 (VI*e*, *f*).

WAITEMATA COUNTY.

The oldest rocks showing within the limits of this county are of Cretaceo-tertiary age, and appear in the vicinity of Wade, and thence extend west and north-west through Dairy Flat and in the direction of Helensville. The lower beds are sandstones and shales, with concretionary boulders; these are overlain by marly clays, followed by hydraulic limestones, which in some places, associated with flint-beds, have a considerable development. Igneous rocks, changed to serpentines, appear through these rocks, and where cutting through the chalky limestones near Wade they are clearly exposed both in natural sections and in quarries, which have been opened in the serpentine for the obtaining of road-metal.

On the hydraulic limestones rest a series of dark sands and sandy clays, which have been referred to as the equivalents of the Orakei Bay beds. In the seacliffs north and south of Lake Takapuna other strata show as alternations of light grey sandstones and dark shaly clays, and are at places fossiliferous, containing Pentacrinus, Bryozoa, and Brachiopods. Following these, and sometimes intermingled with the upper beds, are volcanic breccias and tufa beds that at Cheltenham Beach and north of Lake Takapuna are also fossiliferous. Where the Parnell grit is represented, this, as a fine-grained breccia, must be considered as being truly interbedded, but in the case of the coarser breccias of undoubted volcanic origin the mixture may be assumed to have taken place after the deposition of the sedimentary strata—a matter not surprising in a district where so many points have been centres of volcanic eruption up to a late geological period.

Distinctly overlying all these strata come the trachyte sands and decomposed breccias that extend from the shores of Hauraki Gulf, round the north shores of Manukau Harbour, and, passing underneath the higher part of the coast range north of the entrance to Manukau Harbour, are thus followed by the Manukau breccias, which are indeed but the higher part of this formation. On the Kaipara Flats, and over the low grounds in the neighbourhood of Helensville, recent alluvial deposits are widespread, and sand-dunes occupy the spit of land between the Lower Kaipara and the sea on the west coast. Fossils have been collected from the following localities, indicated as in the case of such localities in other counties: Nos. 539 (III*b*), 695 (IV*c*), 697 (IV*c*?), 731 (III. ?).

WALLACE COUNTY.

The northern portion of this, west of Te Anau Lake, is composed wholly of crystalline rocks. The eastern shores of the lake shows the presence of Tertiary and Cretaceo-tertiary strata, but the bulk of the country on this side shows the presence of the typical rocks of the Te Anau series of Upper Devonian age. In the Takatinui Mountains the same rocks are developed, associated with many intrusive dykes of dioritic and syenitic rocks. The same character of country extends through the Longwood Range to Howell's Point and Orepuki.

Cretaceo-tertiary and Tertiary strata are developed along the Waikau River, below the outlet of Lake Manipouri, and along the southern flanks of the Takatinui Mountains, while Middle Secondary rocks are found at and in the neighbourhood of Morley Creek. Cretaceo-tertiary beds are again found further to the east at the Nightcaps, and to the north on Mount Hamilton. Fossils have been collected at places the localities and numbers of which and the ages of the beds are here given as under: Nos. 30 (VI*g*), 262 (V*b*), 404 (IX*a*), 415 (VI*f*), 453 (IV*c*).

WANGANUI COUNTY.

In the east of the northern part of this river is the great volcanic system of Ruapehu and Tongariro, with the Rangipo desert to the east between Ruapehu and the southern part of the Kaimanawa Range. To the west of the volcanic centre the country is covered with volcanic *débris* to the Wanganui River. However, in the deep channels cut by the tributaries of the Wanganui, Tertiary and at places Cretaceo-tertiary rocks are seen to underlie these superficial deposits. The southern portion of the county is composed of young Tertiary rocks, which, except along the sea-coast, are deeply cut into by the streams draining the country. Fossils have been collected at many places, the Index numbers of which and the ages of the rocks at each locality are here given: Nos. 91 (III*b*), 92 (II*c*), 205 (II*b*), 206 (II*c*) 207 (II*a*), 208 (III*a*), 259 (III., IV.), 633 (II*b*), 634 (II*c*), 635 (II*d*), 636 (II*d*), 638 (II*d*), 639 (III*a*), 640 (III*a*), 641 (III*a*), 645 (III*b*) 647 (III*a*), 648 (III*b*), 649 (V*a*), 650 (VI*a*), 651 (VI*a*), 652 (VI*f*), 653 (III*a*), 659 (III*a*), 660 (III*a*).

WHAKATANE COUNTY.

The main range of the North Island is continued from south-west to north-east, along the eastern side of this county. The water-parting and the highest peaks of range are not, however, always formed of Old Secondary or Palæozoic rocks. These on the east side of this area lie within the watersheds of the Whakatane and Motu Rivers and the lesser streams falling into the Bay of Plenty. Between the source of the Whakatane and Lake Waikare-moana the whole of the eastern slopes of the main range, and for six or seven miles down the north-west slope, the rocks are of Tertiary or Cretaceo-tertiary date, and it is only the outer ranges, bounding the upper Whakatane or Ruatahuna Plain, that are formed of the older rocks. These are ordinary slates and sandstones not differing from the more common rocks of the main range generally. The main source branch of the Whakatane runs close under the steep slopes of the mountains, bounding the river valley on the north-west side. Where the Maori track, from Waikare-moana to Ahikereru, crosses six or seven miles above Ruatahuna Pa, the terrace descent from the plain to the river-bed amounts to fully 200ft., the river-bed at the crossing being 900ft. above the sea. The Ruatahuna Plain is three to four miles wide, and about twenty miles in length, and has the appearance of having at one time been the site of a lake, but all the shingle seen at the surface indicates river-action. The mountains on the western side of the Whakatane, and occupying the whole county to the Rangitaiki River, are also mainly formed of Old Secondary and Palæozoic slates and sandstones, but here and there the rocks are of a more calcareous description than is met with in the mountains on the east side of the valley. At one place within these western mountains white compact limestone, forming a kind of marble, is found. Nowhere is there evidence of metallic wealth in these mountains, and lodes of vein-quartz are extremely rare, and never of any considerable size. Masses of trachyte rock are met with in the bed of the Whakatane River, near its source, and looking toward the south-western sources of the river the mountains appear to be capped by a sheet of grey rock, forming vertical precipices that is the probable source of the boulders observed. In the Ahikereru Basin trachyte rock and drift pumice fill the low grounds till the river-valley gorges, and the stream begins to break through the outer range of mountains on its way to join the Rangitaiki. Along the Upper Motu the older rocks are confined to the west and north-west side of the valley. To the east the main water-parting and highest peaks of the range are formed of Cretaceo-tertiary rocks. The highest rocks of this series, and those also attaining the greatest elevation above the sea, are a calcareous greensand, which appears to be a representative of the Cobden limestone of the South Island. Before the Motu turns sharp to the west and again to the north, ten miles above where it falls into the Bay of Plenty, it cuts deeply into Cretaceo-tertiary chalky limestone, and forms a tremendous and almost impassable gorge. To the north-east of the Motu River the shore-line to the Raupokoro River is formed of old rocks, except where Pleistocene leaf-bearing deposits may be here and there present. In Te Kaha Peninsula black calcareous shales and masses of flinty chert are the most prominent rocks; the latter contains traces of copper. From the Raupokoro to Oreti Point the rocks are of Young Secondary age, but beyond this Tertiary rocks again occupy the coast-line till reaching the volcanic series of Cape Runaway. The interior of this part of the country shows the presence of Tertiary rocks resting on the Old Secondary Palæozoic series, but the main water-divide between the Bay of Plenty and the Waipaoa Valley is again Young Secondary rocks.

Fossils have been collected as below, indicated by the Index numbers of the localities, the ages of the beds being also indicated:— Nos. 679 (II*c*), 682 (III*a*), 705 (II*b*).

WESTLAND COUNTY.

The western slopes of the New Zealand Alps form the great feature of this area. These are composed on this side in their lower slopes of granite, overlain by mica-schist of different varieties, while the greater heights of the mountains forming the main water-parting, even the highest peak of the whole range, are formed of rocks belonging to the Te Anau and Maitai series. In the southern portion, south of Jackson's Bay, intrusive olivine rocks, often changed to serpentine, form a prominent feature in the Olivene Range and in Red Mountain. Maitai rocks lie between this and the coast-line, and there is also a development of Cretaceo-tertiary and also of Tertiary rocks in the the same part of the district.

Further to the north, between Arnott's Point and the Paringa River, the coal-bearing series, containing seams of bituminous coal, is developed, followed by fossiliferous greensands and the higher members of the Cretaceo-tertiary series. The lithographic limestone of Abbey Rocks corresponds to the Cobden limestone at Greymouth, and the volcanic rocks at the mouth of the Paringa River are of the same age.

In the northern part of the county both Cretaceo-tertiary and Tertiary rocks are developed on the banks of the Kanieri River, and Tertiary rocks are developed between the Totara and Mokihinui Rivers on the slopes of the hills inland of Ross's Flat.

South of Ross to Bruce Bay the great feature of the coast-line is the enormous amount of fragmental matter which, glacier-carried from the high inland ranges, has been deposited on the coast-line as the terminal moraines of huge glaciers descending from the western slopes of the Southern Alps. These deposits have been considerably encroached upon by the sea within recent times, and now present a long line of high cliffs washed by the tide, and at many places it is difficult or impossible to pass the base of these at or near high water.

Fossils have been collected at localities of which the Index numbers and the ages of the beds are here given: Nos. 26 (III*d*), 153 (III*d*), 154 (IV*b*), 155 (III*c*), 156 (VI*e*), 225 (III*d*), 227 (IV*b*), 291 (XII*a*), 428 (VI.).

WEST TAUPO COUNTY.

The greater part of this is at least superficially overspread by volcanic brecciated rocks and pumice-sands, the proceeds of the great volcanoes of the central region of the North Island.

Here and there, especially in the western part, isolated ranges of Old Secondary or Palæozoic rocks rise above and stand out from the general covering of igneous material. Tertiary and Cretaceo-tertiary rocks probably underlie in the volcanic districts along the Upper Wanganui or Tuhua River. No fossiliferous rocks are known within this area.

WHANGAREI COUNTY.

The coast-line north of Whangarei Harbour is mostly formed of Old Secondary or Palæozoic rocks, and these, with the southern part of Puhipuhi Forest, form part of the Puhipuhi Silverfield. The same rocks at the southern extremity of the county form Bream Tail, and the old rocks of the same line of elevation extended to the north-west are deeply cut into and well exposed in the Waipa Gorge. Cretaceo-tertiary rocks, and the underlying rocks of the Amuri series, have a considerable development within the county, the lower or Amuri series being principally developed in the western part of the county. Volcanic rocks, whether as lava-streams or detrital matter, occupy a considerable area, especially in the neighbourhood of Whangarei and Kamo, and these obscure alike the older rocks and those of Cretaceo-tertiary date over considerable areas.

The coal-bearing areas of Kamo and Hikurangi, perhaps, in the best manner display the sequence of the Cretaceo-tertiary rocks, but in the southern part of the area a short distance inland of the settlement of Waipu, the Whangarei limestones, and the underlying rocks belonging to the same series, are well exposed. Limestone Island, in Whangarei Harbour, is composed of hydraulic limestone, the northern representative of the Amuri limestone in the South Island, and near Whangarei Heads fossiliferous rocks belonging to the same sequence are exposed. Fossils have been collected from localities of which the Index numbers and ages of the beds are given below: Nos. 199 (VI*e*), 270 (VI*f*), 271 (VI*e*), 275 (VI*f*), 279 (VI*f*), 282 (VI*f*), 283 (VI*f*), 284 (VI*e*), 416 (VI*f*), 464 (VI*d*).

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DIRECTOR.

REPORTS

OF

GEOLOGICAL EXPLORATIONS

DURING 1890–91.

WITH MAPS AND SECTIONS.

PUBLISHED BY COMMAND.

NEW ZEALAND:
BY AUTHORITY: GEORGE DIDSBURY, GOVERNMENT PRINTER, WELLINGTON.
1891.